

# Field Evaluation Alphasense OPC-N3 Sensor



# Background

- From 08/15/2018 to 10/11/2018, three **Alphasense OPC-N3** sensors were deployed at a SCAQMD stationary ambient monitoring site in Rubidoux and were run side-by-side with three reference instruments measuring the same pollutants
- Alphasense OPC-N3 (3 units tested):
  - Particle sensor (**optical; non-FEM**)
  - Each unit measures: PM<sub>1.0</sub>, PM<sub>2.5</sub> and PM<sub>10</sub> (µg/m<sup>3</sup>), Temperature (°C), Relative Humidity (%)
  - **Unit cost: ~\$340**
  - Time resolution: 10-sec
  - Units IDs: 0217, 0218, 0219
  - Differences from OPC-N2:
    - Increased particle size range: 0.38 - 40 µm and channels: 24 software bins
    - Equipped with onboard temperature and humidity sensor that is enclosed in raw sensor housing
    - Auto switching when detecting higher range
    - Increased sampling flow rate to 5.5 L/min
- MetOne BAM (reference instrument):
  - Beta-attenuation monitor (**FEM PM<sub>2.5</sub> & PM<sub>10</sub>**)
  - Measures PM<sub>2.5</sub> & PM<sub>10</sub> (µg/m<sup>3</sup>)
  - **Unit cost: ~\$20,000**
  - Time resolution: 1-hr
- GRIMM (reference instrument):
  - Optical particle counter (**FEM PM<sub>2.5</sub>**)
  - Measures PM<sub>1.0</sub>, PM<sub>2.5</sub>, and PM<sub>10</sub> (µg/m<sup>3</sup>)
  - **Cost: ~\$25,000 and up**
  - Time resolution: 1-min
- Teledyne API T640 (reference instrument):
  - Optical particle counter (**FEM PM<sub>2.5</sub>**)
  - Measures PM<sub>2.5</sub> & PM<sub>10</sub> (µg/m<sup>3</sup>)
  - **Unit cost: ~\$21,000**
  - Time resolution: 1-min

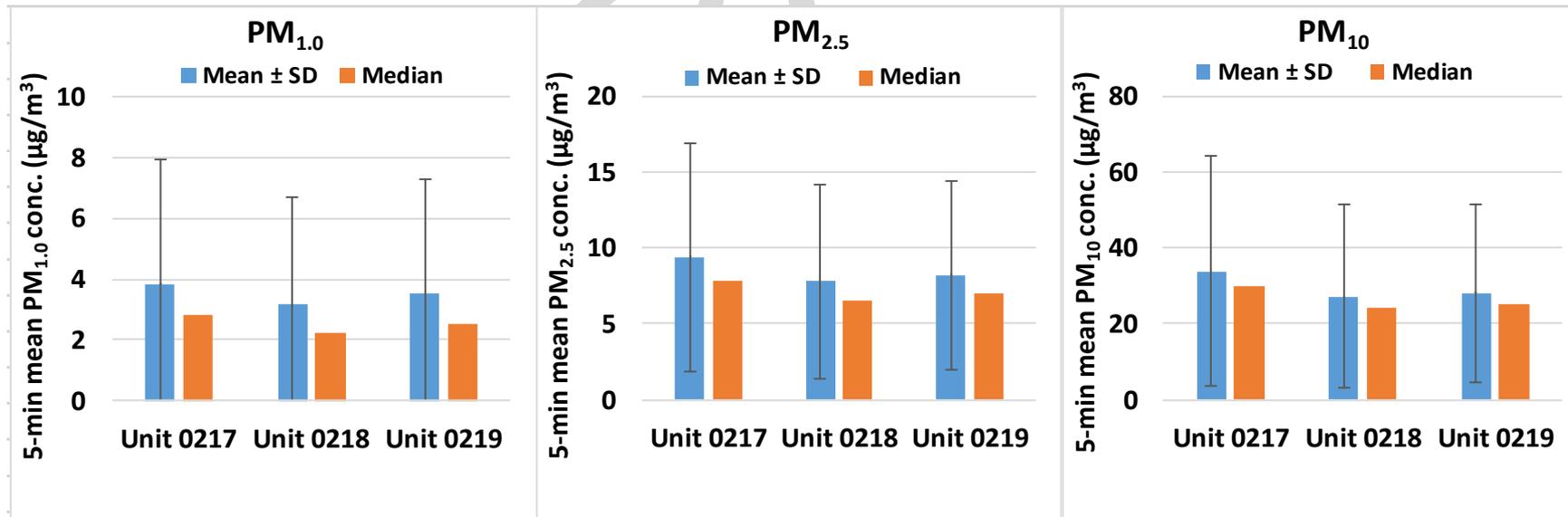


# Data validation & recovery

- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values and invalid data-points were eliminated from the data-set)
- Data recovery for  $PM_{1.0}$ ,  $PM_{2.5}$  and  $PM_{10}$  from all three units was close to 100%

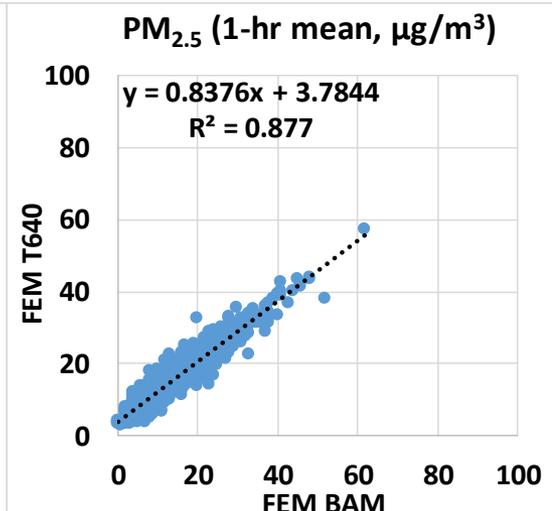
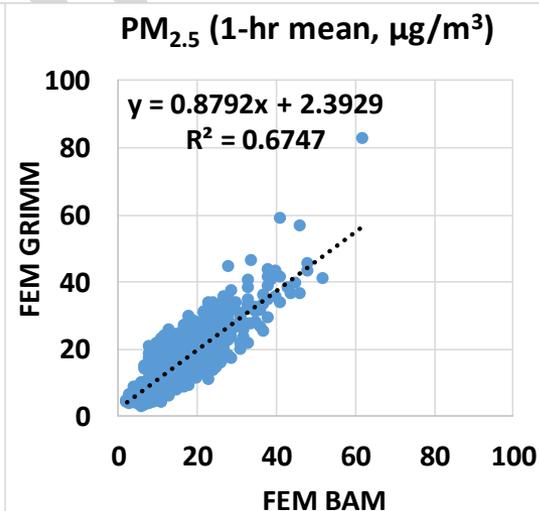
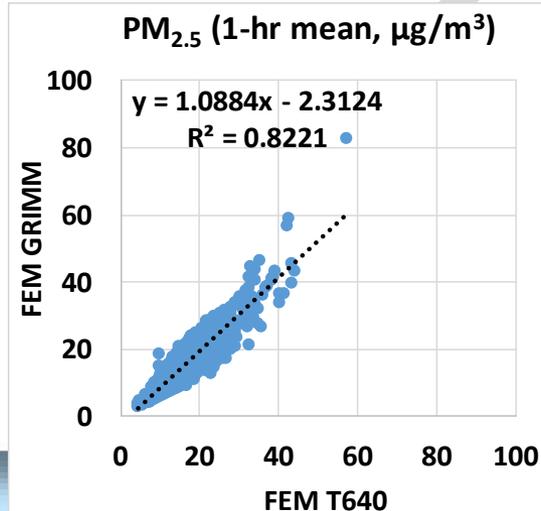
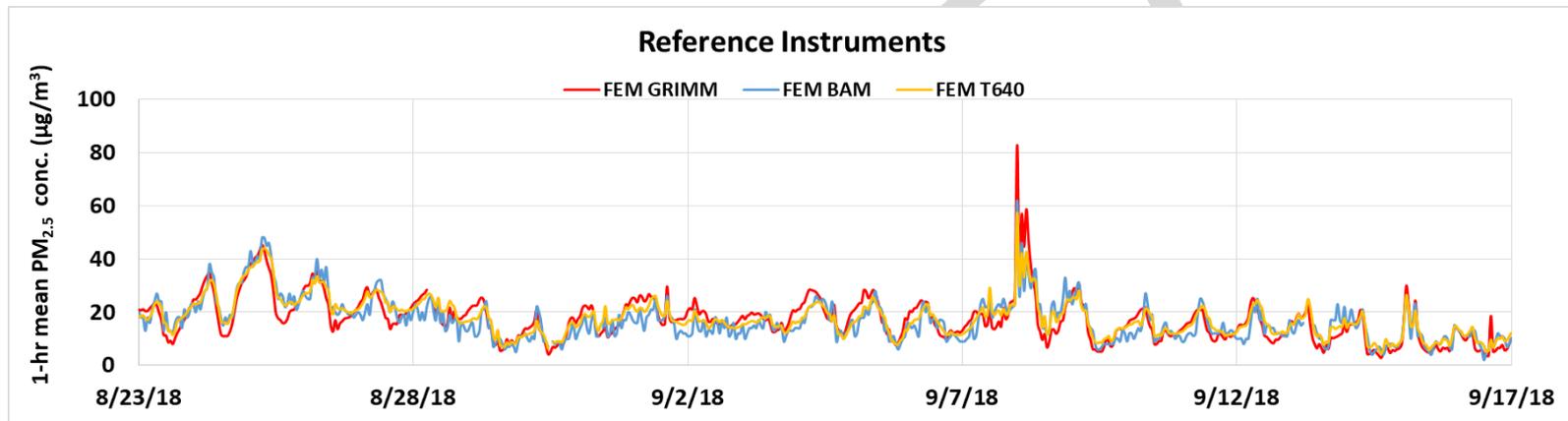
## Alphasense OPC-N3; intra-model variability

- Low-to-moderate measurement variability (18-22%) was observed between the three Alphasense OPC-N3 units for  $PM_{1.0}$ ,  $PM_{2.5}$  and  $PM_{10}$



# Reference Instruments: GRIMM, BAM & T640

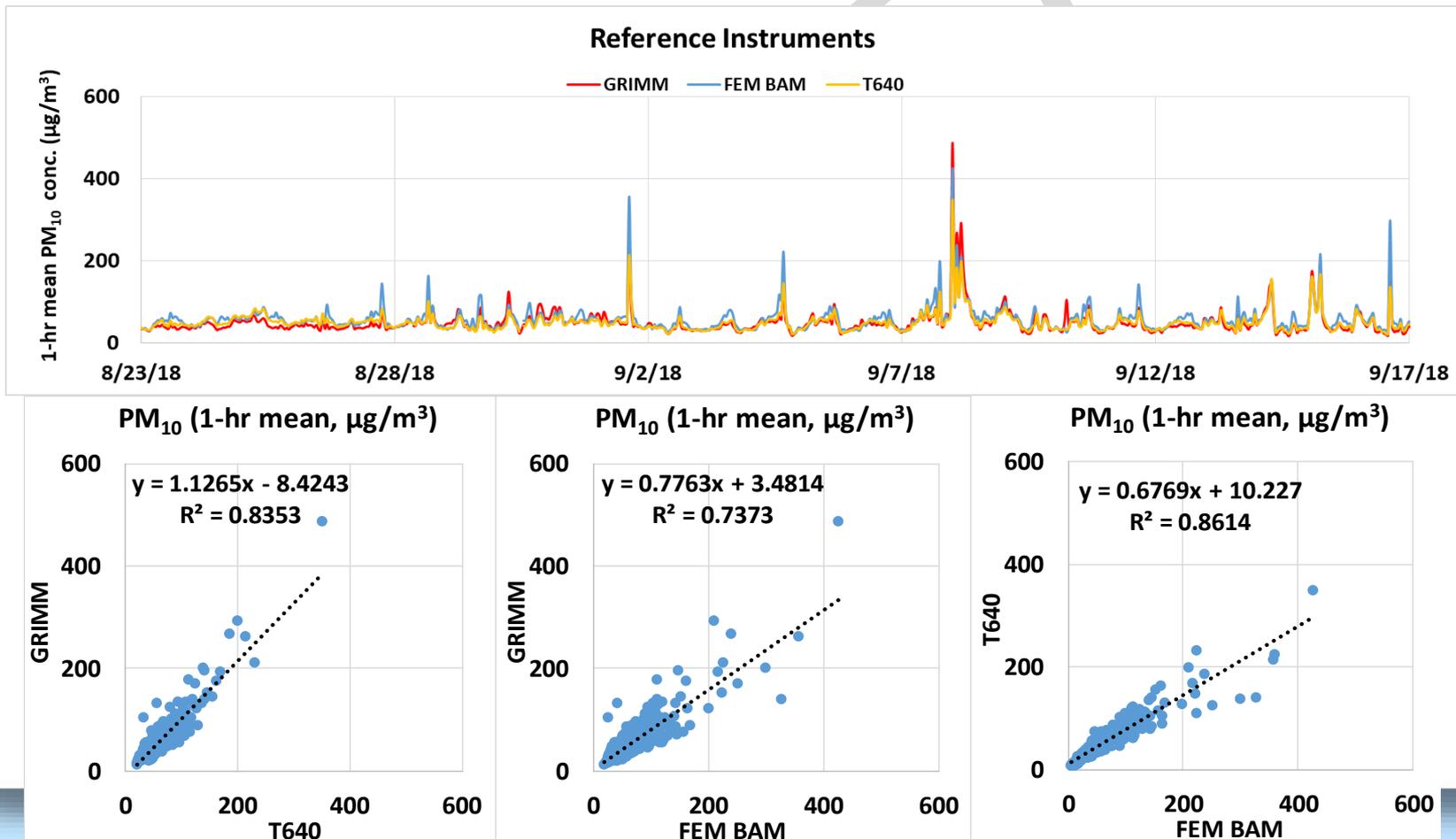
- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values and invalid data-points were eliminated from the data-set)
- Data recovery for PM<sub>2.5</sub> from FEM GRIMM, FEM BAM and FEM T640 is 79%, 99% and 100%, respectively
- Good correlations between the three reference instruments for PM<sub>2.5</sub> measurements ( $0.67 < R^2 < 0.88$ )



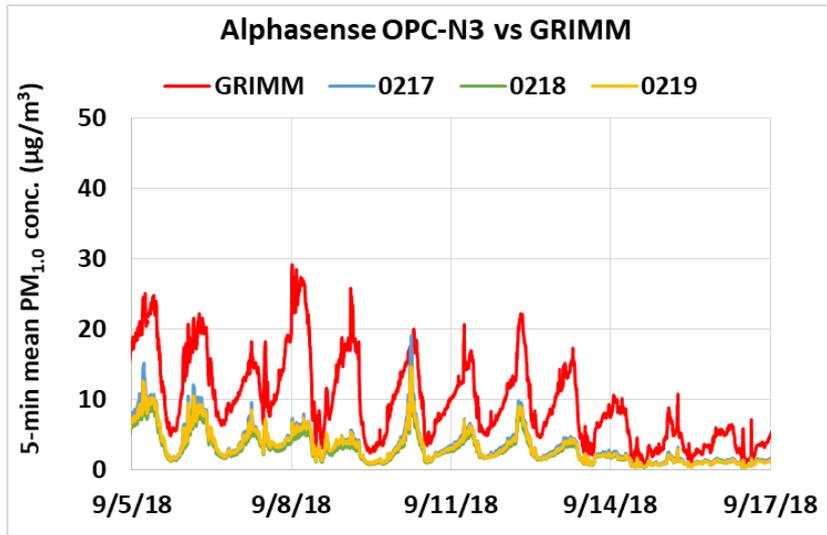
# Reference Instruments

## GRIMM, BAM & T640

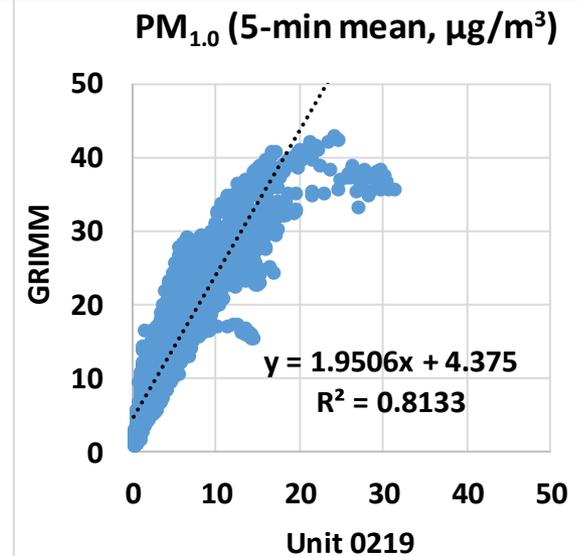
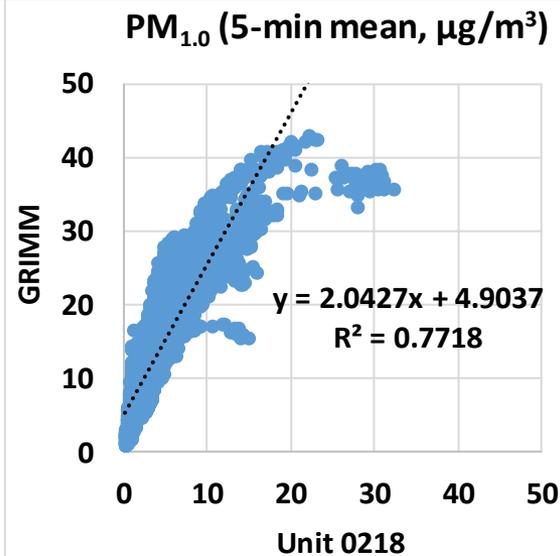
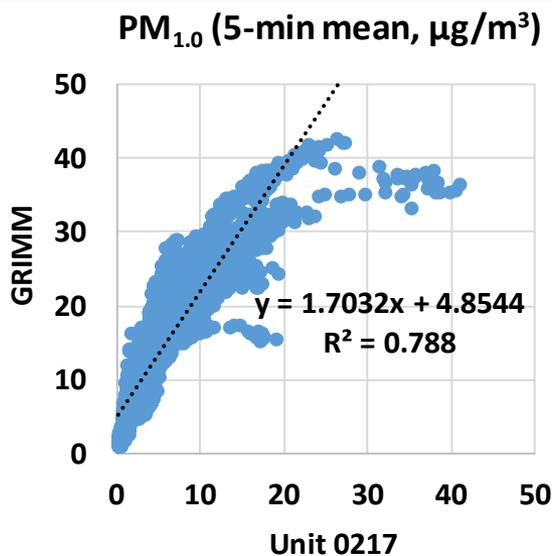
- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values and invalid data-points were eliminated from the data-set)
- Data recovery for PM<sub>10</sub> from GRIMM, FEM BAM and T640 is 79%, 99% and 100%, respectively
- Good correlations between the three reference instruments for PM<sub>10</sub> measurements ( $0.73 < R^2 < 0.87$ )



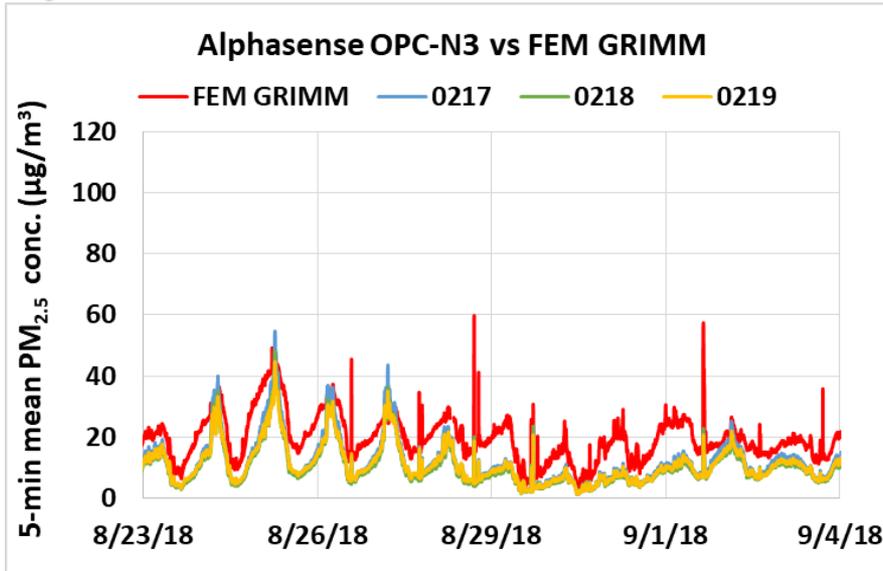
# Alphasense OPC-N3 vs GRIMM (PM<sub>1.0</sub>; 5-min mean)



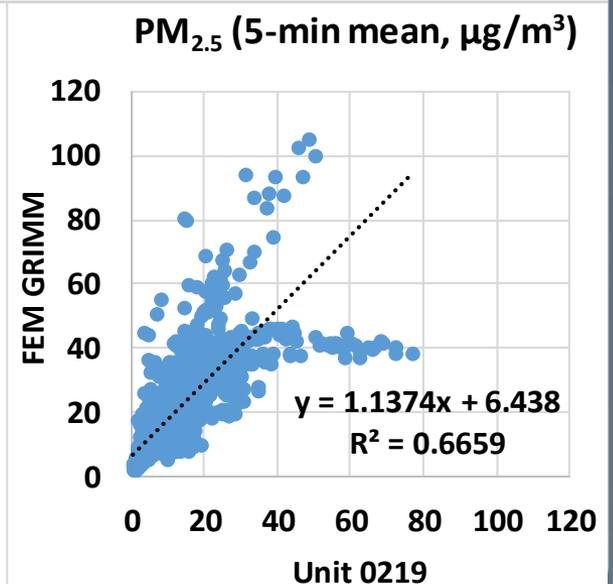
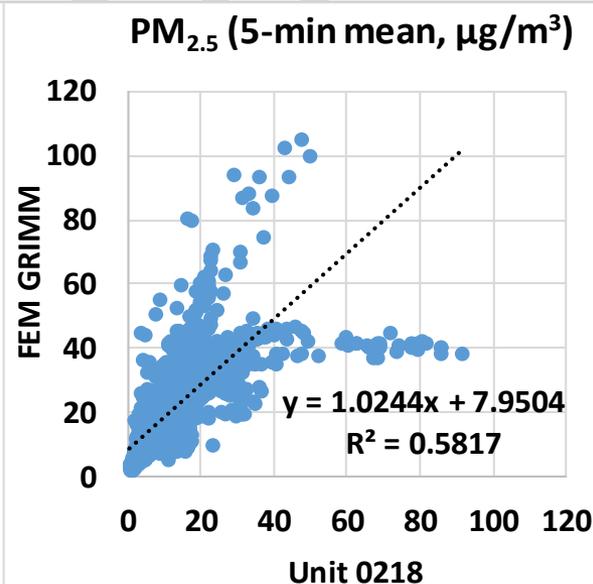
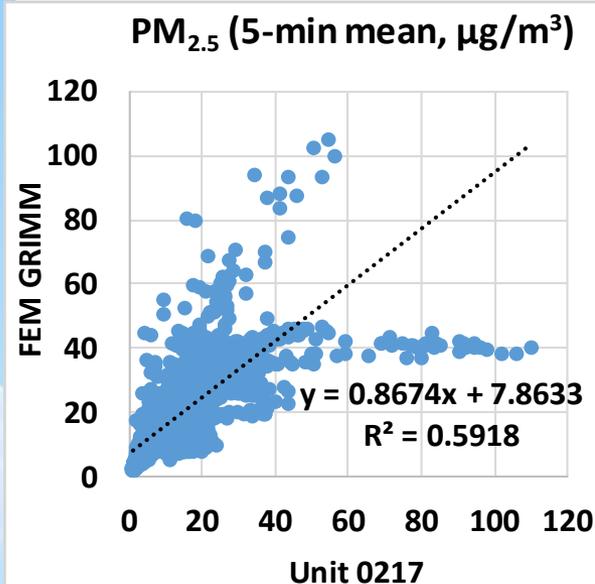
- The Alphasense OPC-N3 sensors correlate well with the corresponding GRIMM data ( $R^2 \sim 0.79$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>1.0</sub> mass concentrations measured by GRIMM
- The Alphasense OPC-N3 sensors seem to track well the PM<sub>1.0</sub> diurnal variations as recorded by GRIMM



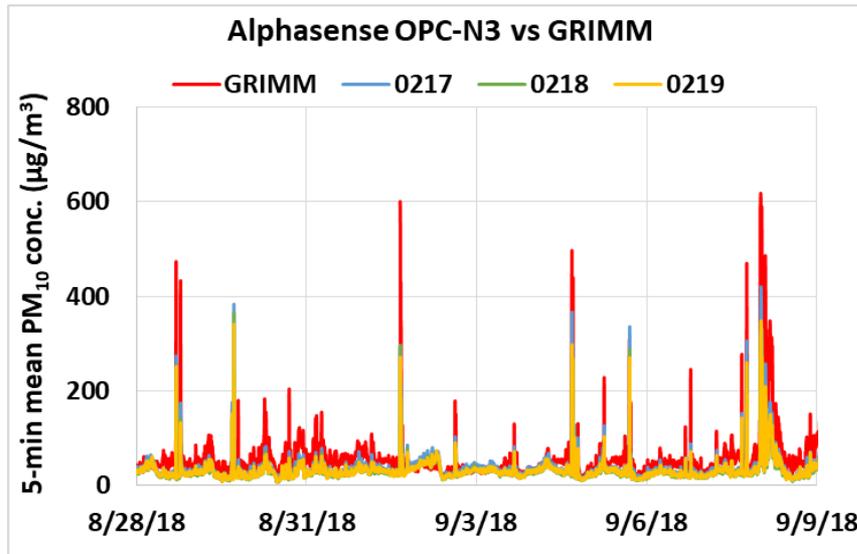
# Alphasense OPC-N3 vs FEM GRIMM (PM<sub>2.5</sub>; 5-min mean)



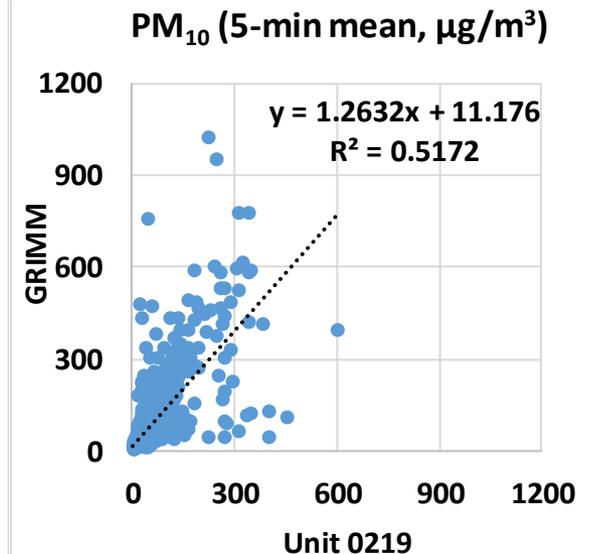
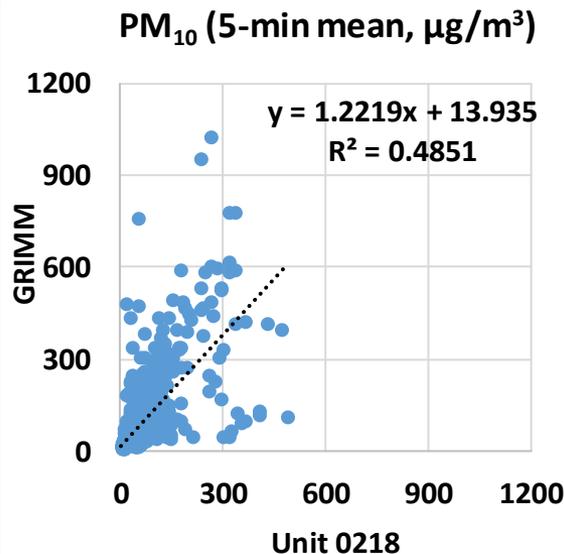
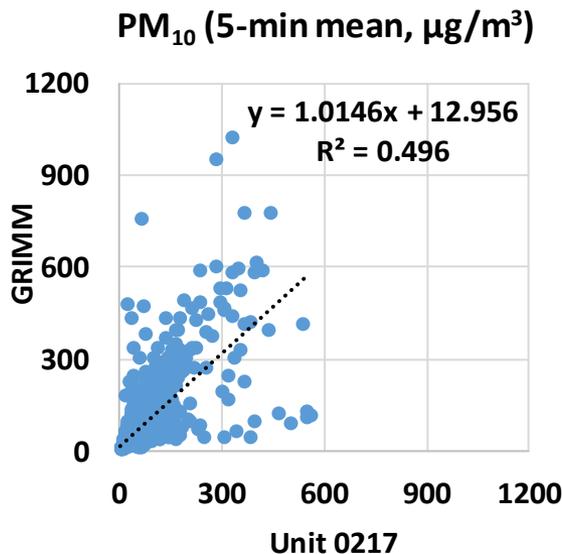
- The Alphasense OPC-N3 sensors show moderate correlations with the corresponding FEM GRIMM data ( $R^2 \sim 0.61$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>2.5</sub> mass concentrations measured by FEM GRIMM
- The Alphasense OPC-N3 sensors seem to track well the PM<sub>2.5</sub> diurnal variations as recorded by FEM GRIMM



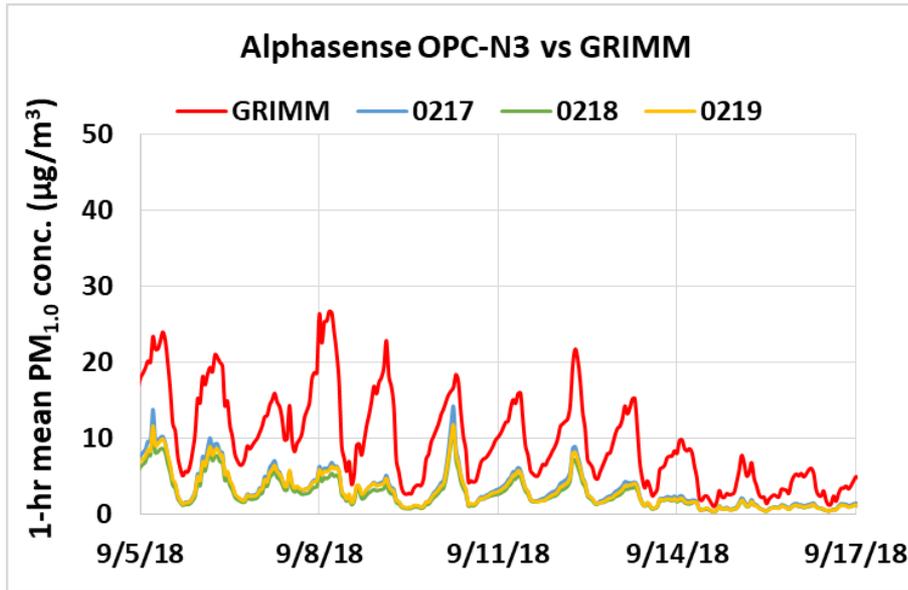
# Alphasense OPC-N3 vs GRIMM (PM<sub>10</sub>; 5-min mean)



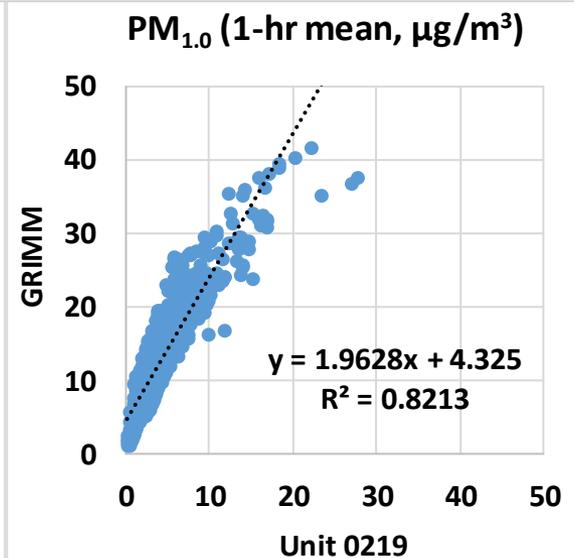
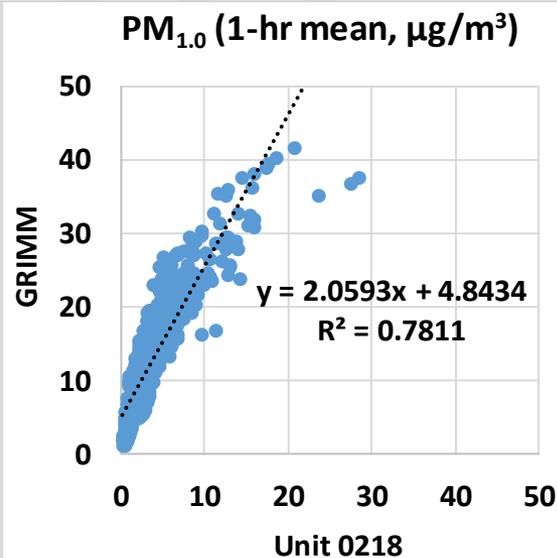
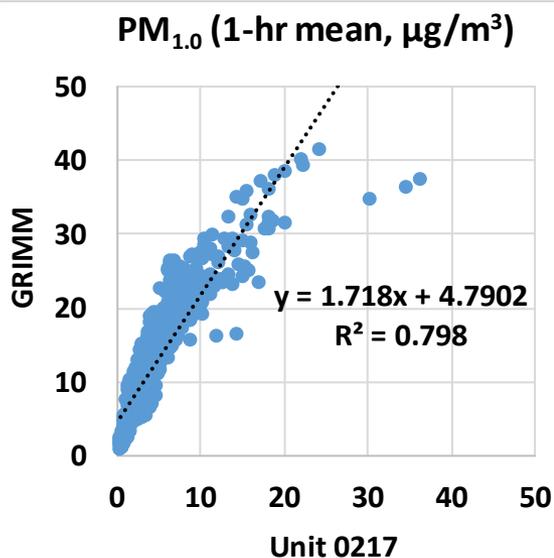
- The Alphasense OPC-N3 sensors show moderate correlations with the corresponding GRIMM data ( $R^2 \sim 0.5$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>10</sub> mass concentrations measured by GRIMM
- The Alphasense OPC-N3 sensors seem to track the PM<sub>10</sub> diurnal variations as recorded by GRIMM



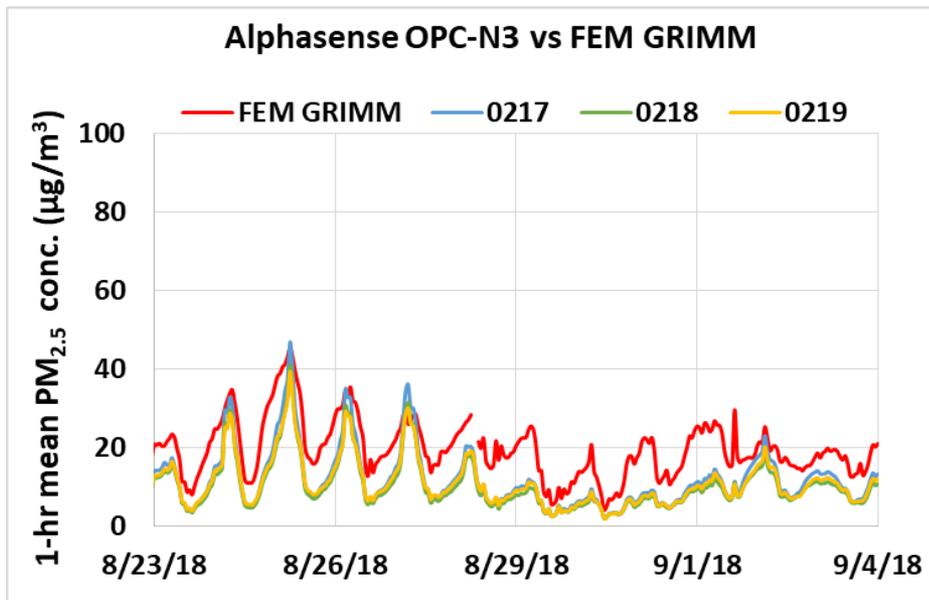
# Alphasense OPC-N3 vs GRIMM (PM<sub>1.0</sub>; 1-hr mean)



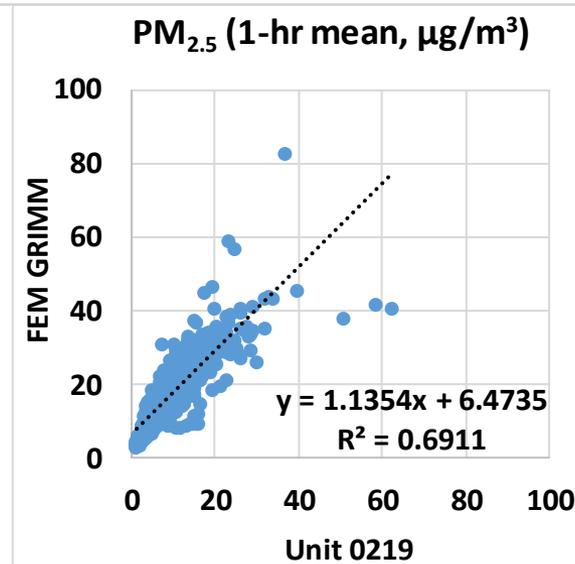
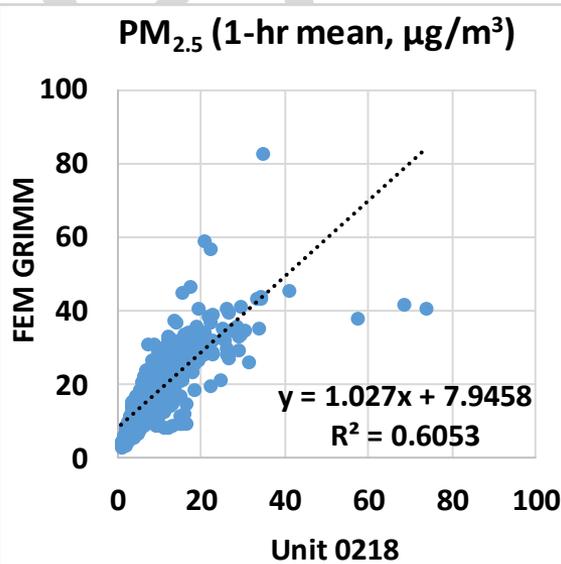
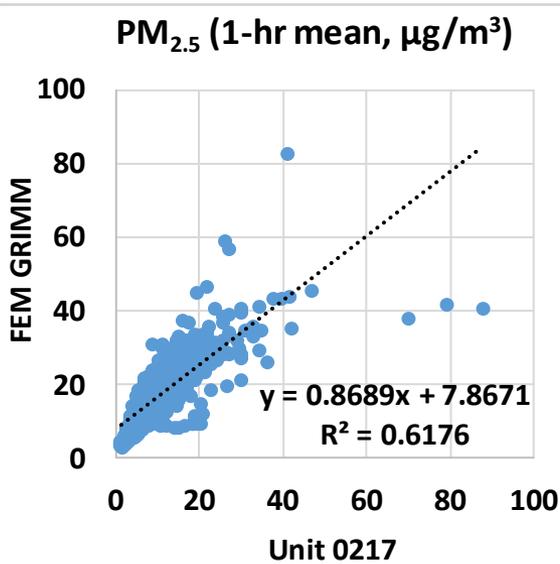
- The Alphasense OPC-N3 sensors correlate well with the corresponding GRIMM data ( $R^2 \sim 0.80$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>1.0</sub> mass concentrations measured by GRIMM
- The Alphasense OPC-N3 seem to track well the PM<sub>1.0</sub> diurnal variations as recorded by GRIMM



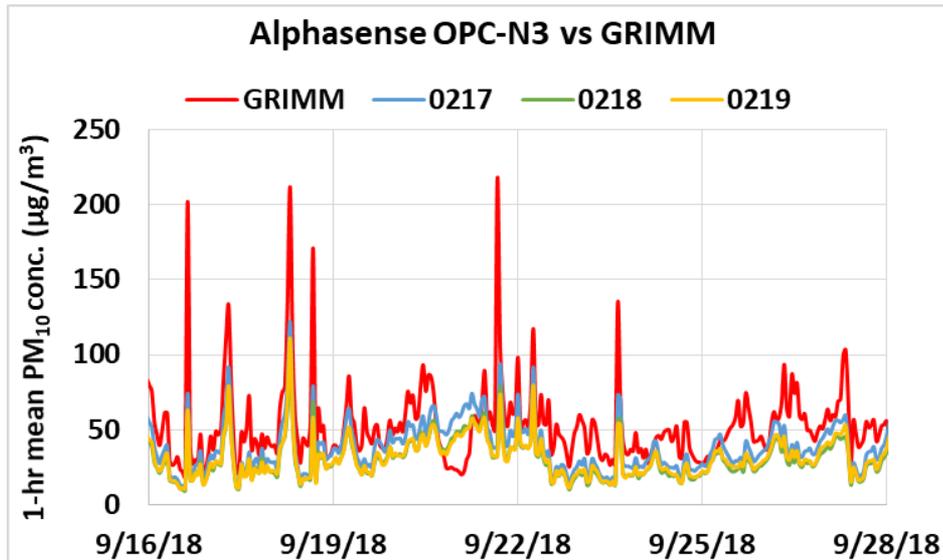
# Alphasense OPC-N3 vs FEM GRIMM (PM<sub>2.5</sub>; 1-hr mean)



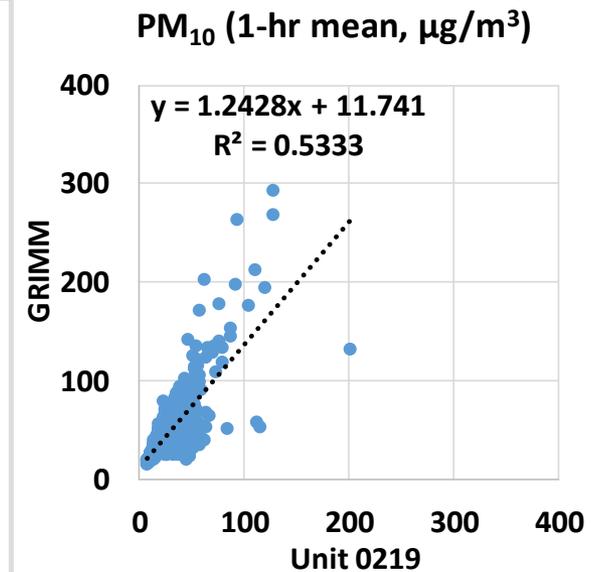
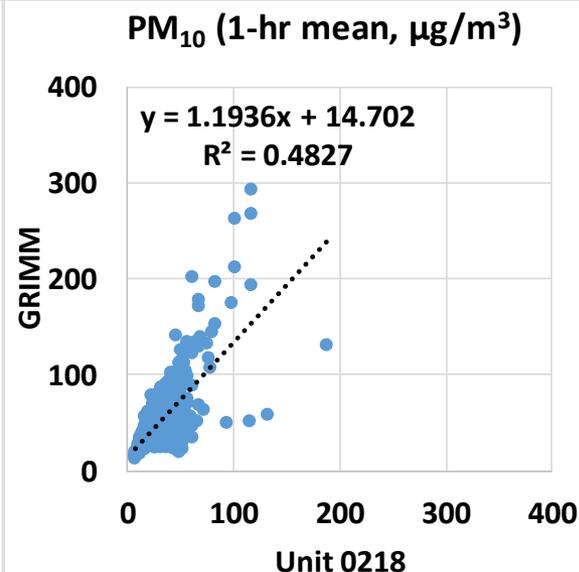
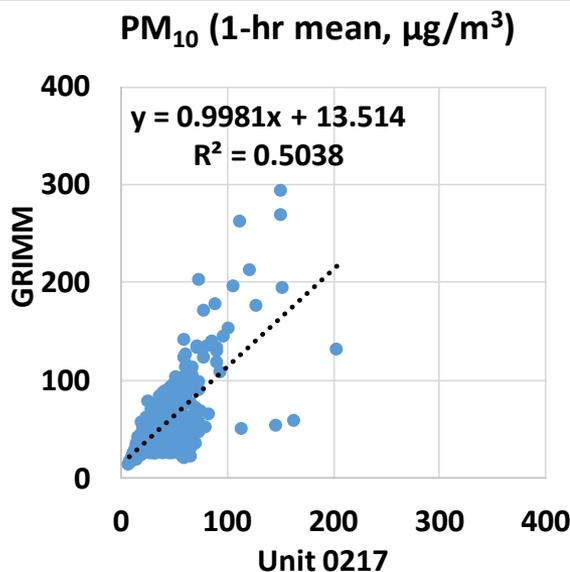
- The Alphasense OPC-N3 sensors show good correlations with the corresponding FEM GRIMM data ( $R^2 \sim 0.64$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>2.5</sub> mass concentrations measured by FEM GRIMM
- The Alphasense OPC-N3 seem to track well the PM<sub>2.5</sub> diurnal variations as recorded by FEM GRIMM



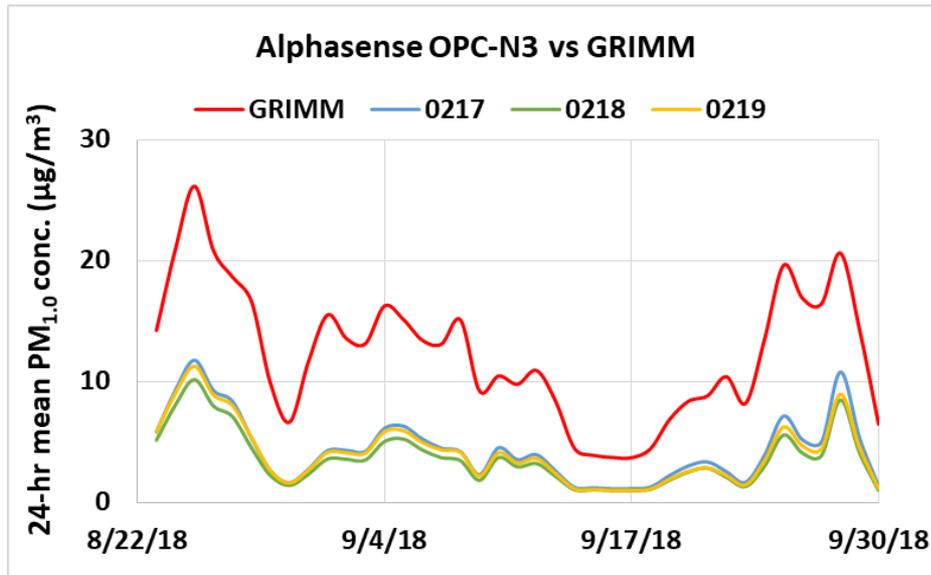
# Alphasense OPC-N3 vs GRIMM (PM<sub>10</sub>; 1-hr mean)



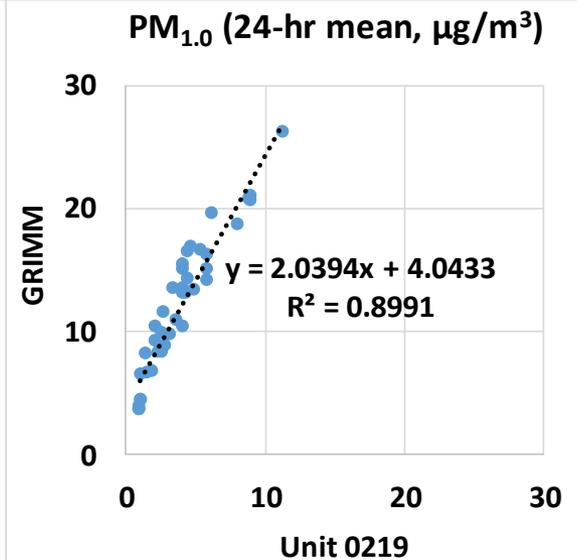
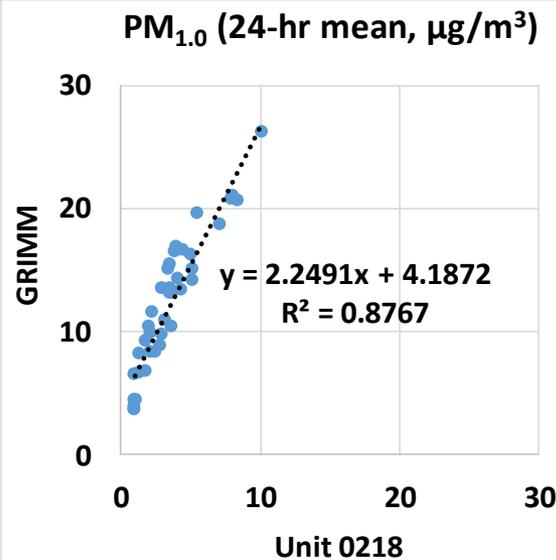
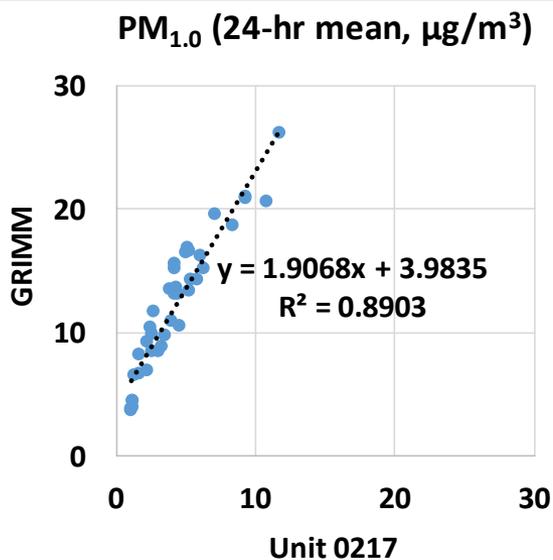
- The Alphasense OPC-N3 sensors show moderate correlations with the corresponding GRIMM data ( $R^2 \sim 0.51$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>10</sub> mass concentrations measured by GRIMM
- The Alphasense OPC-N3 seem to track well the PM<sub>10</sub> diurnal variations as recorded by GRIMM



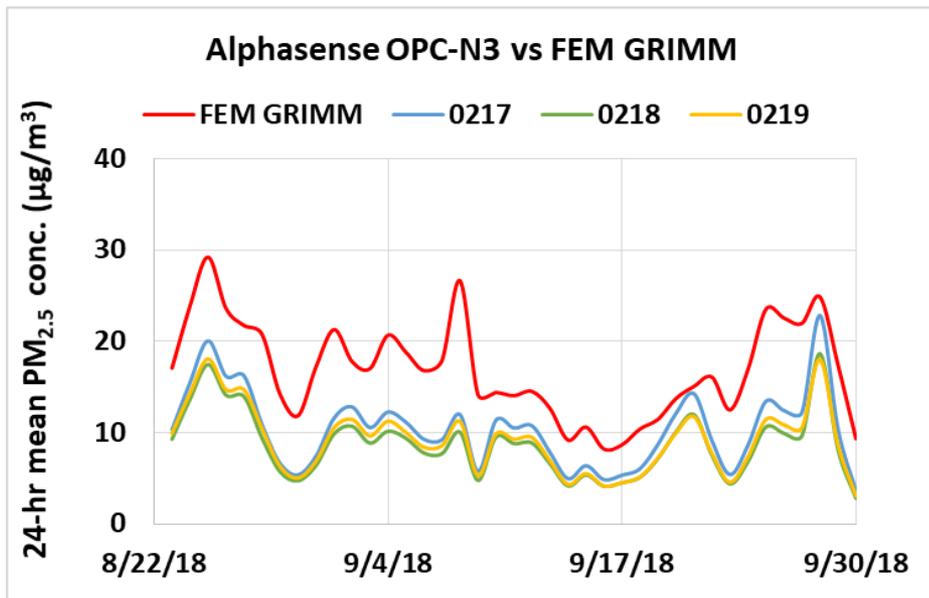
# Alphasense OPC-N3 vs GRIMM (PM<sub>1.0</sub>; 24-hr mean)



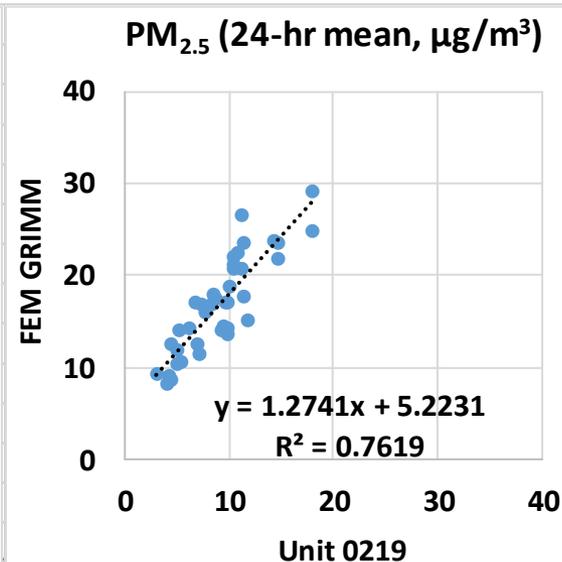
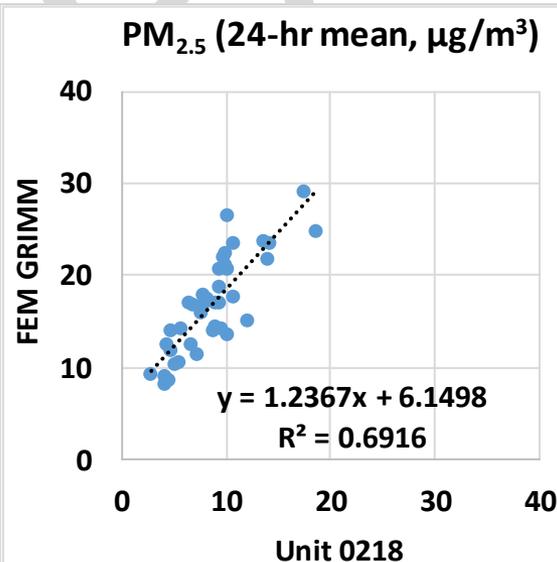
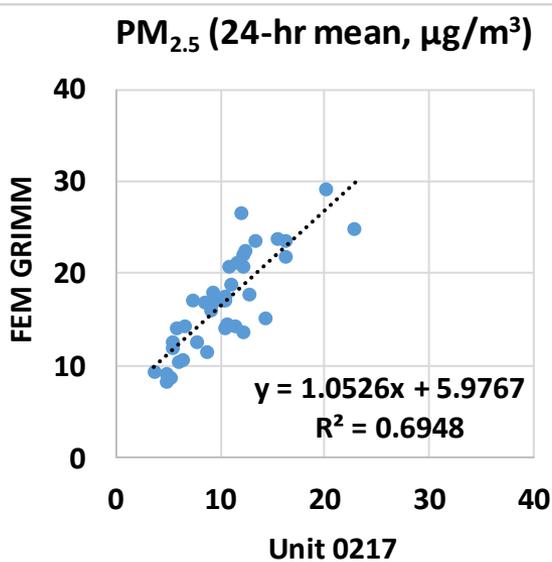
- The Alphasense OPC-N3 sensors correlate well with the corresponding GRIMM data ( $R^2 \sim 0.89$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>1.0</sub> mass concentrations measured by GRIMM
- The Alphasense OPC-N3 seem to track well the PM<sub>1.0</sub> concentration variations as recorded by GRIMM



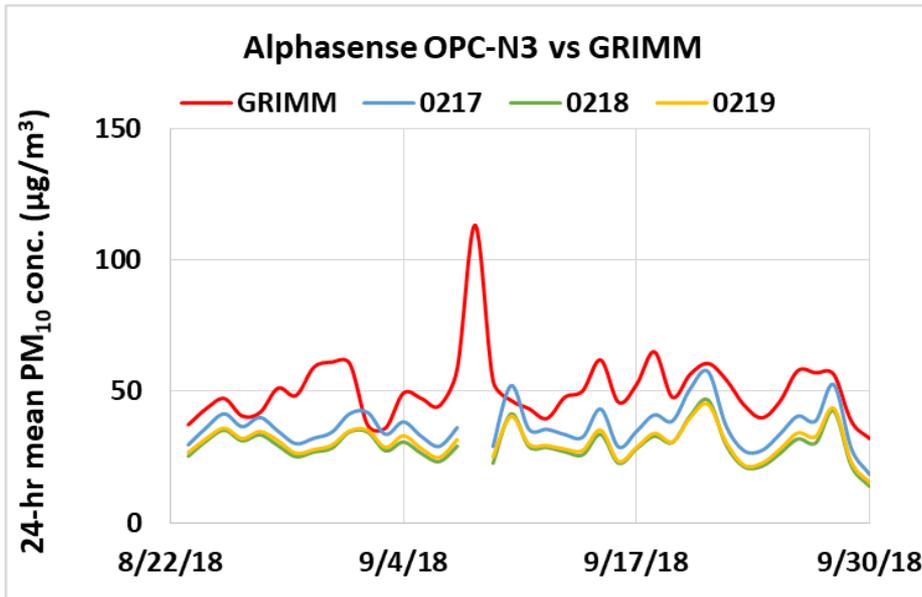
# Alphasense OPC-N3 vs FEM GRIMM (PM<sub>2.5</sub>; 24-hr mean)



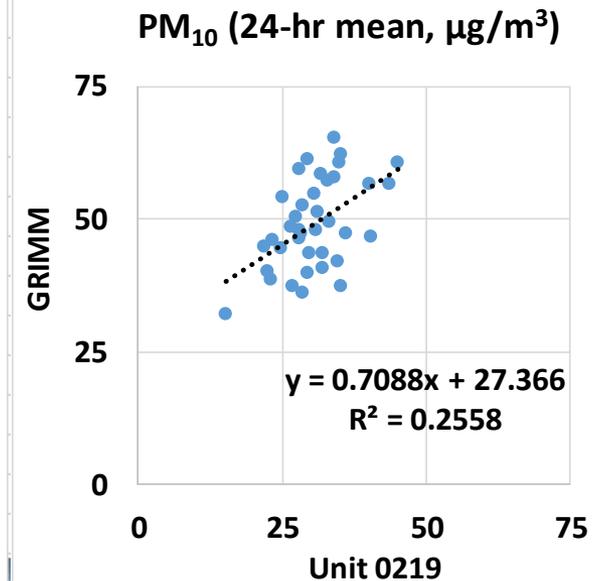
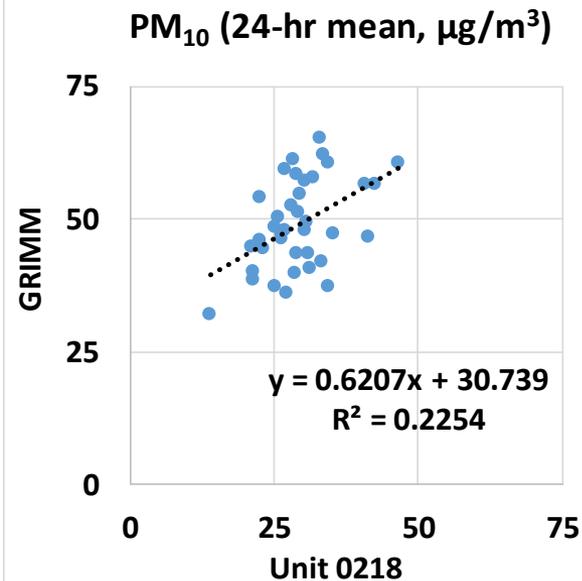
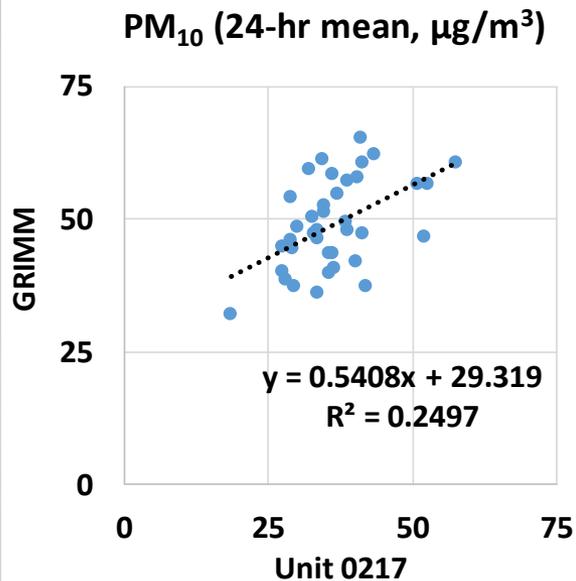
- The Alphasense OPC-N3 sensors show good correlations with the corresponding FEM GRIMM data ( $R^2 \sim 0.72$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>2.5</sub> mass concentrations measured by FEM GRIMM
- The Alphasense OPC-N3 seem to track well the PM<sub>2.5</sub> concentration variations as recorded by FEM GRIMM



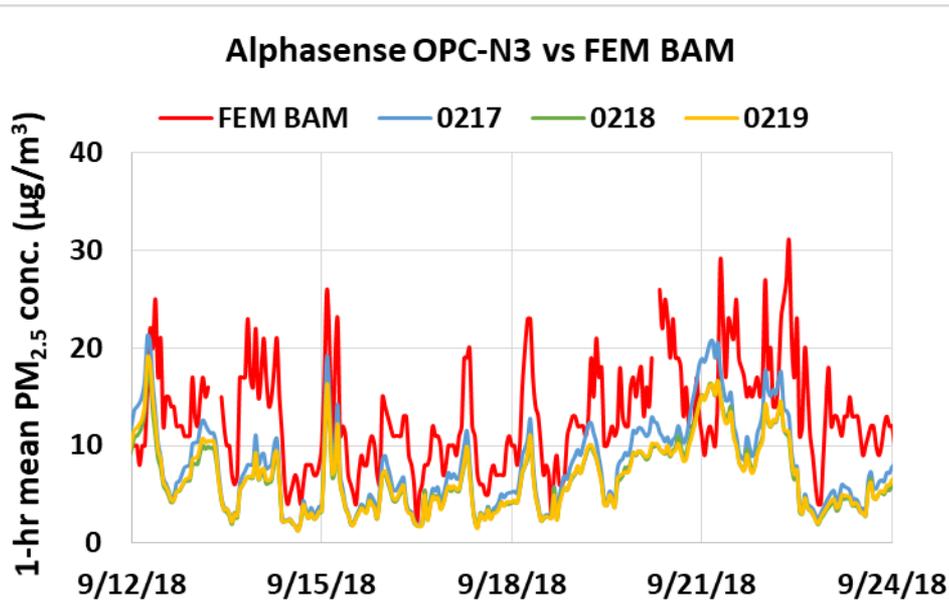
# Alphasense OPC-N3 vs GRIMM (PM<sub>10</sub>; 24-hr mean)



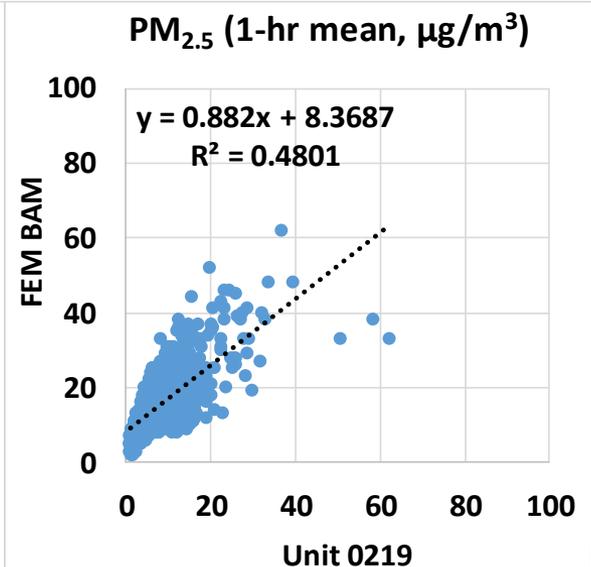
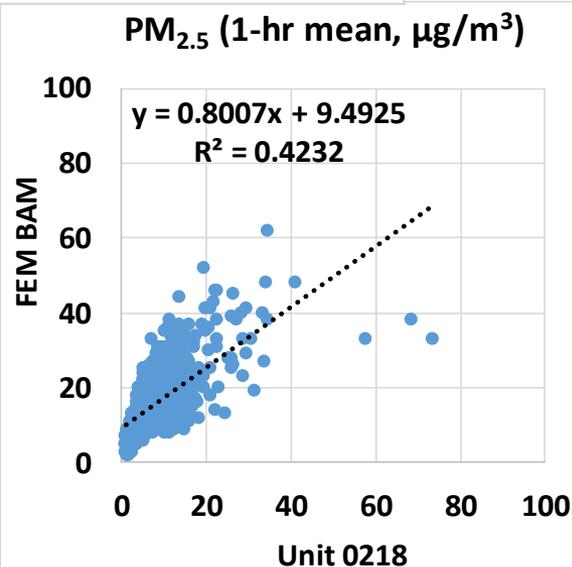
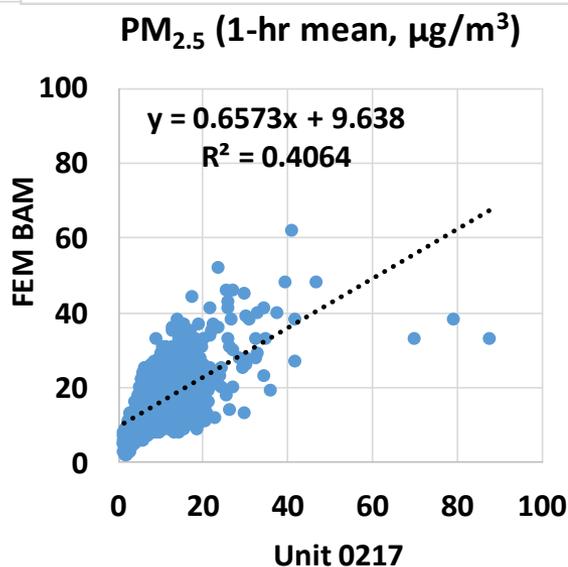
- The Alphasense OPC-N3 sensors correlate poorly with the corresponding GRIMM data ( $R^2 \sim 0.24$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>10</sub> mass concentrations measured by GRIMM
- The Alphasense OPC-N3 seem to track well the PM<sub>10</sub> concentration variations as recorded by GRIMM



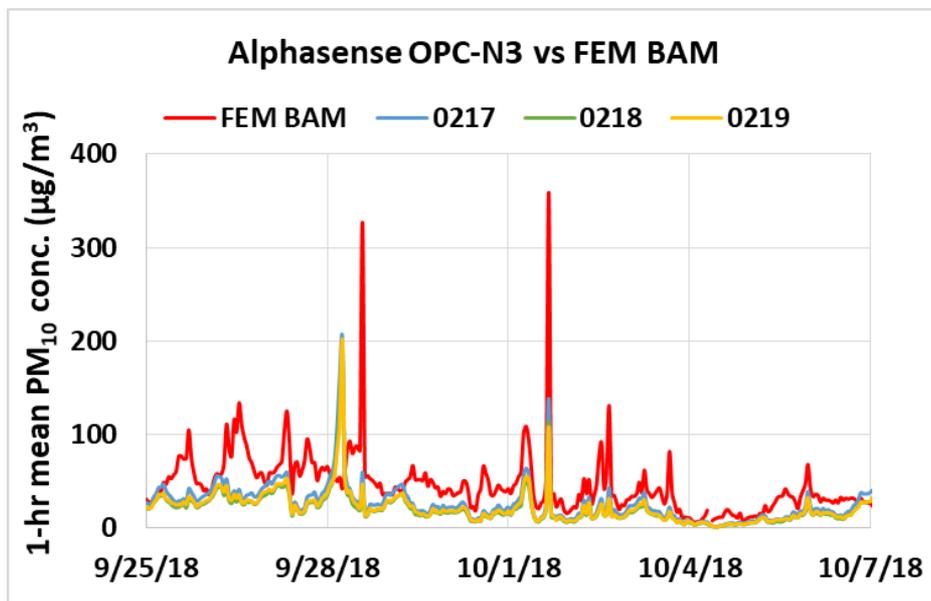
# Alphasense OPC-N3 vs FEM BAM (PM<sub>2.5</sub>; 1-hr mean)



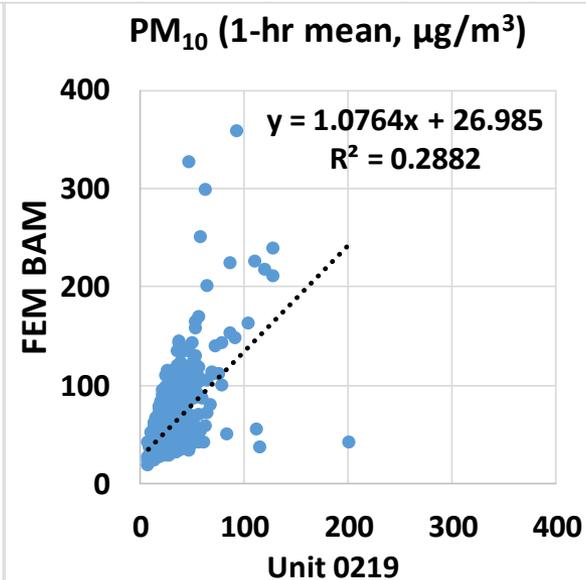
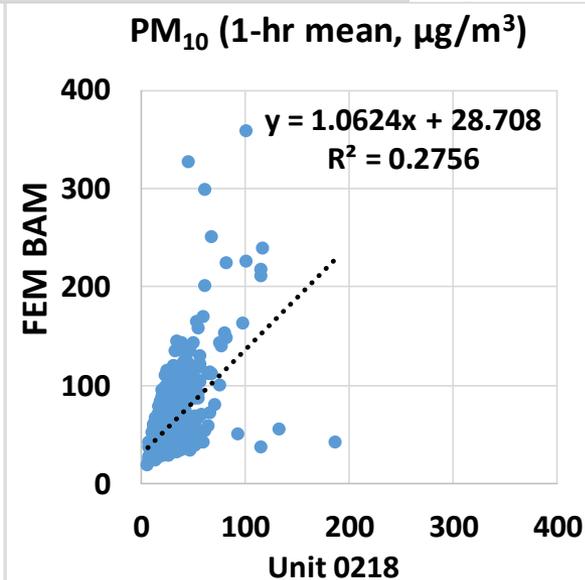
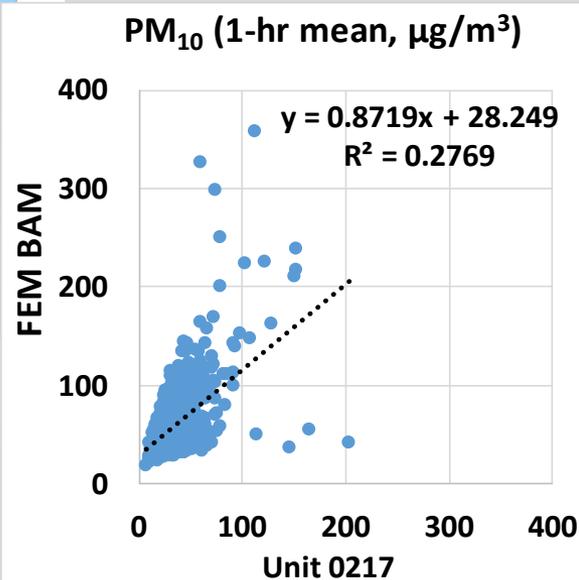
- The Alphasense OPC-N3 sensors show moderate correlations with the corresponding FEM BAM data ( $R^2 \sim 0.44$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>2.5</sub> mass concentrations measured by FEM BAM
- The Alphasense OPC-N3 seem to track the PM<sub>2.5</sub> diurnal variations as recorded by FEM BAM



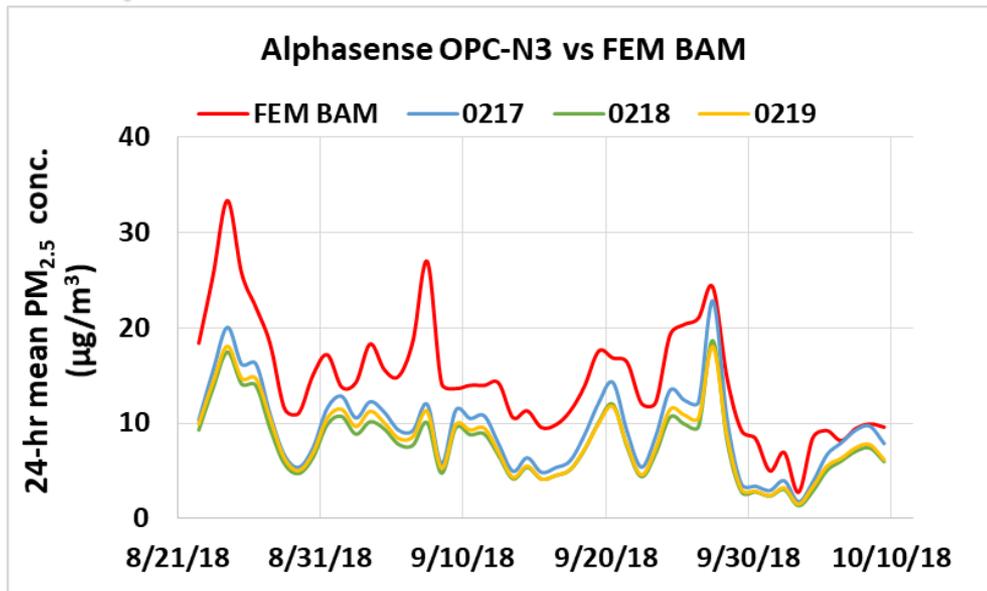
# Alphasense OPC-N3 vs FEM BAM (PM<sub>10</sub>; 1-hr mean)



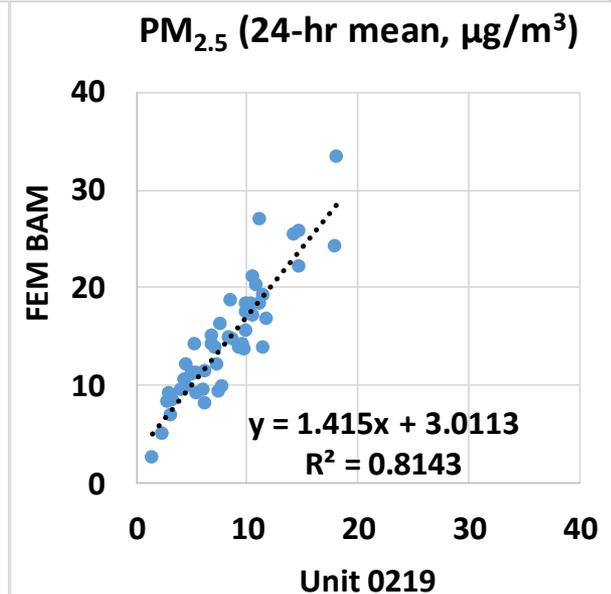
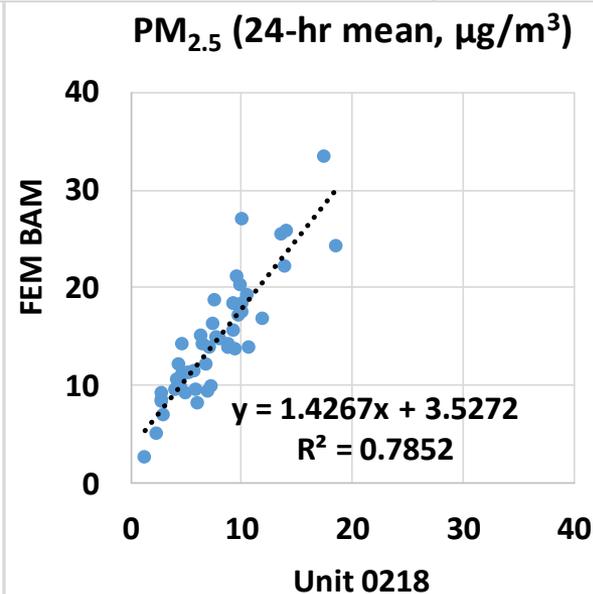
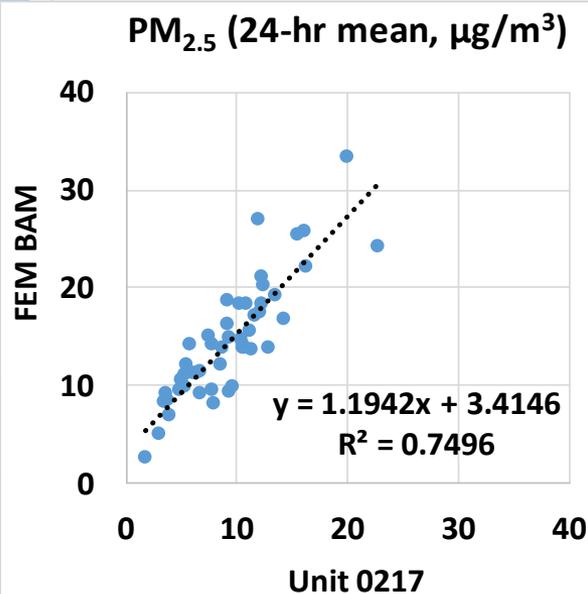
- The Alphasense OPC-N3 sensors correlate poorly with the corresponding FEM BAM data ( $R^2 \sim 0.28$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>10</sub> mass concentrations measured by FEM BAM
- The Alphasense OPC-N3 seem to modestly track the PM<sub>10</sub> diurnal variations as recorded by FEM BAM



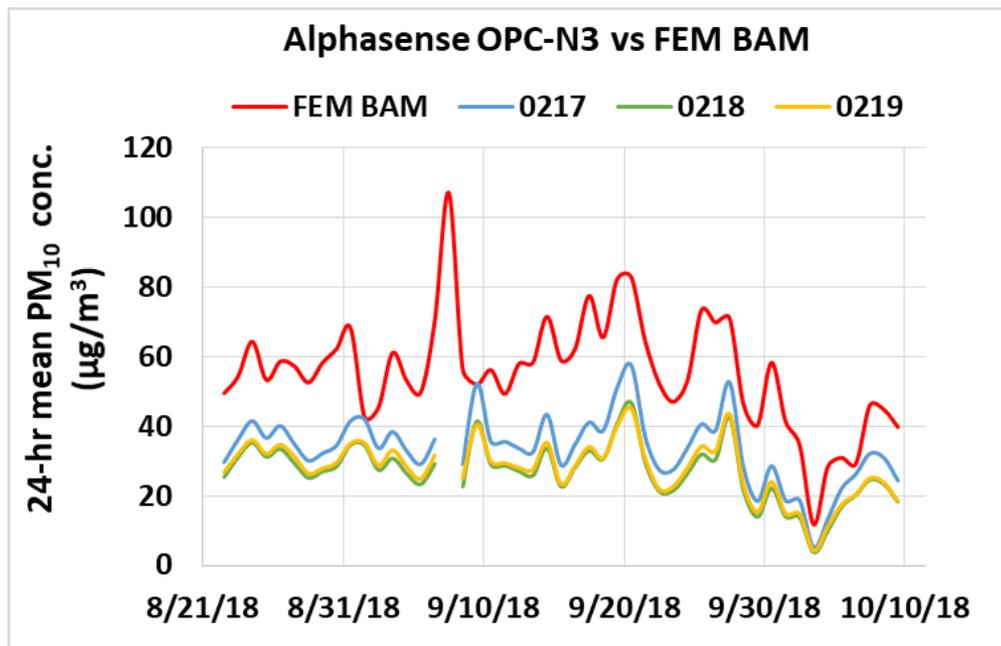
# Alphasense OPC-N3 vs FEM BAM (PM<sub>2.5</sub>; 24-hr mean)



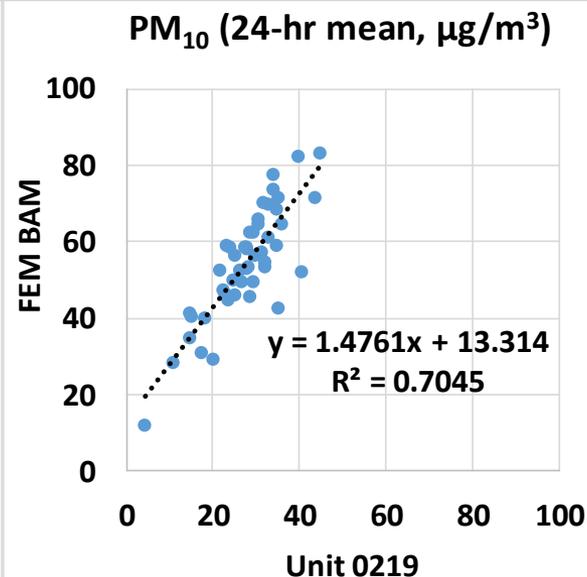
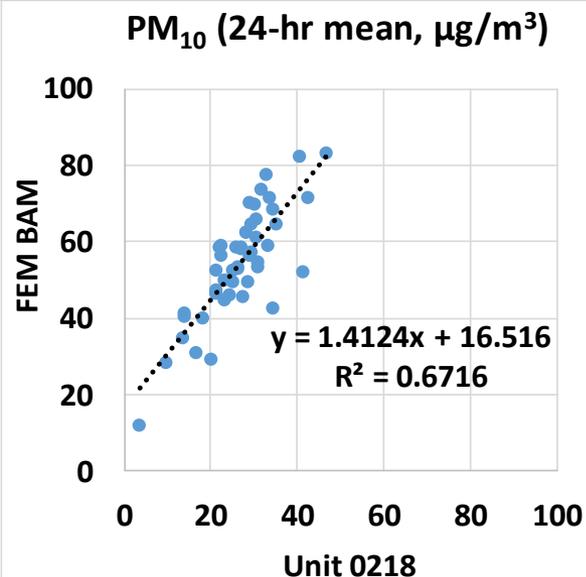
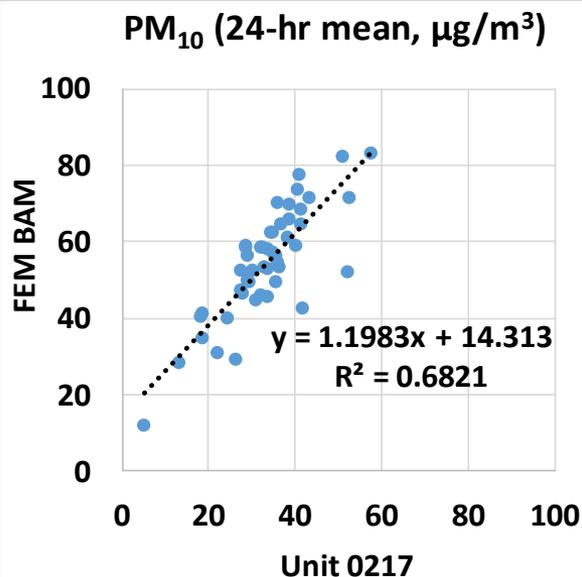
- The Alphasense OPC-N3 sensors show good correlations with the corresponding FEM BAM data ( $R^2 \sim 0.78$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>2.5</sub> mass concentrations measured by FEM BAM
- The Alphasense OPC-N3 seem to track well the PM<sub>2.5</sub> concentration variations as recorded by FEM BAM



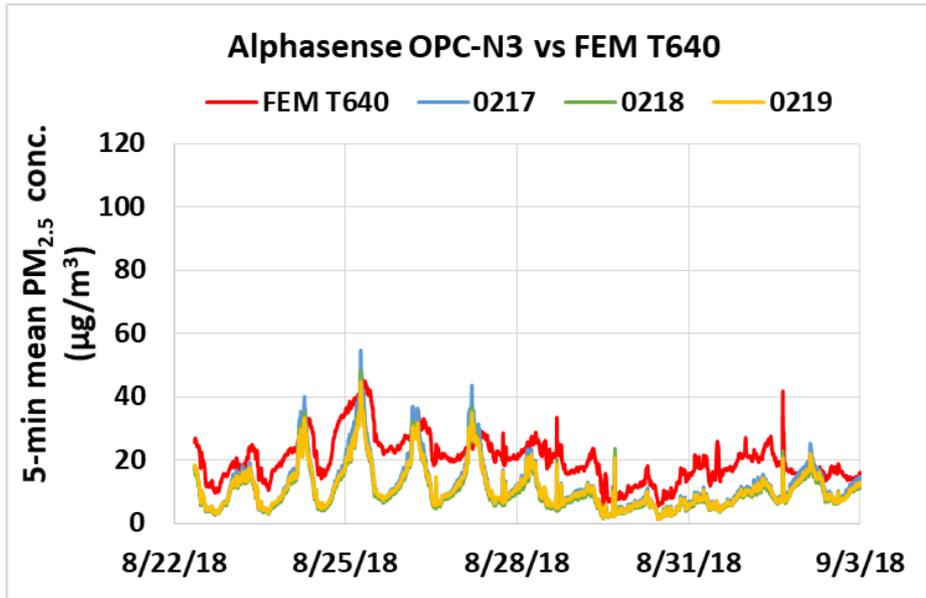
# Alphasense OPC-N3 vs FEM BAM (PM<sub>10</sub>; 24-hr mean)



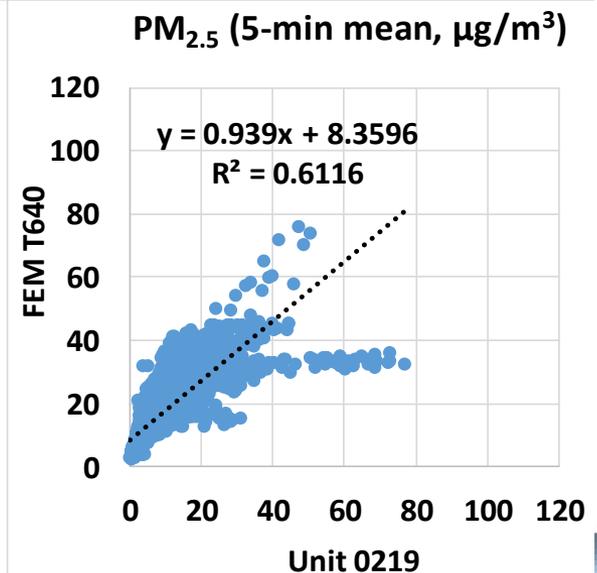
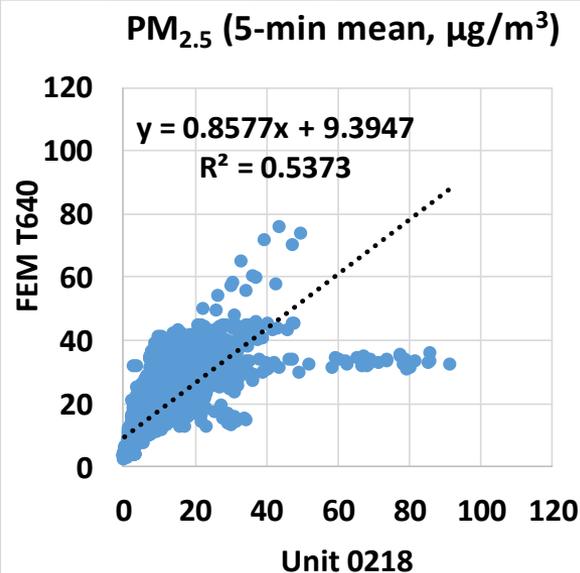
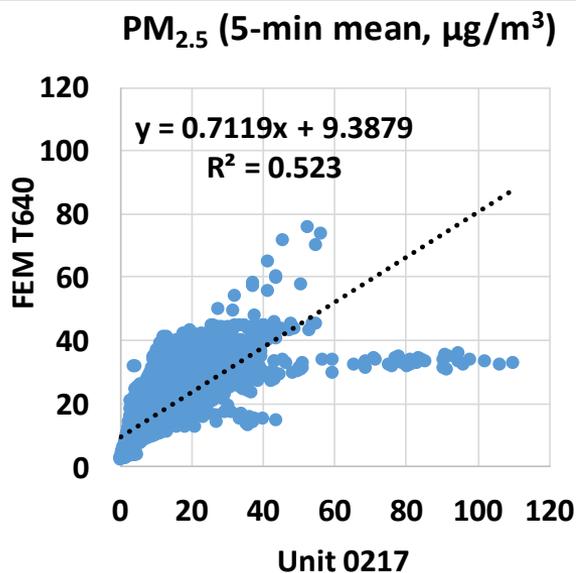
- The Alphasense OPC-N3 sensors show good correlations with the corresponding FEM BAM data ( $R^2 \sim 0.69$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>10</sub> mass concentrations measured by FEM BAM
- The Alphasense OPC-N3 seem to track well the PM<sub>10</sub> concentration variations as recorded by FEM BAM



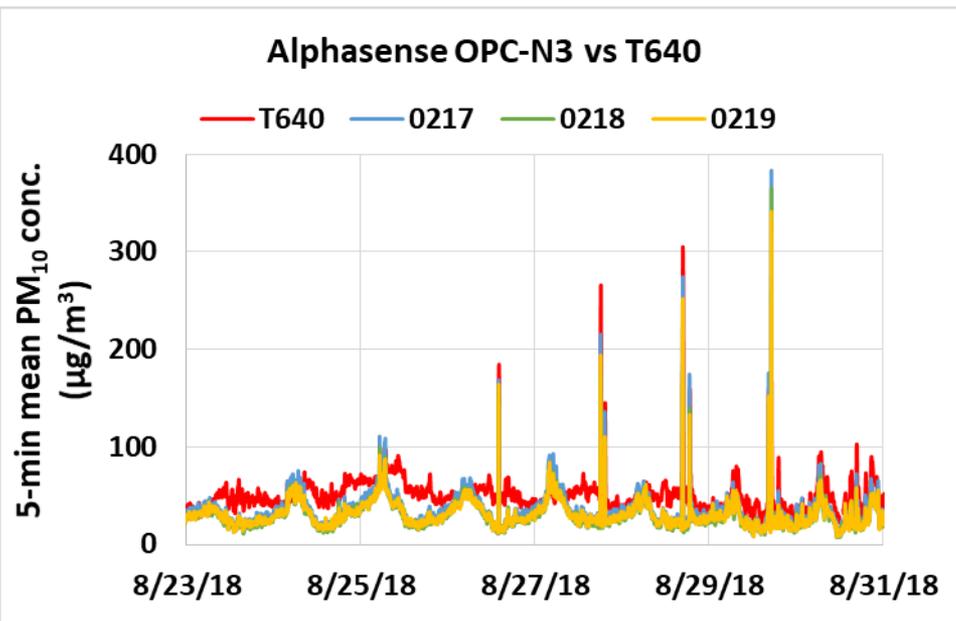
# Alphasense OPC-N3 vs FEM T640 (PM<sub>2.5</sub>; 5-min mean)



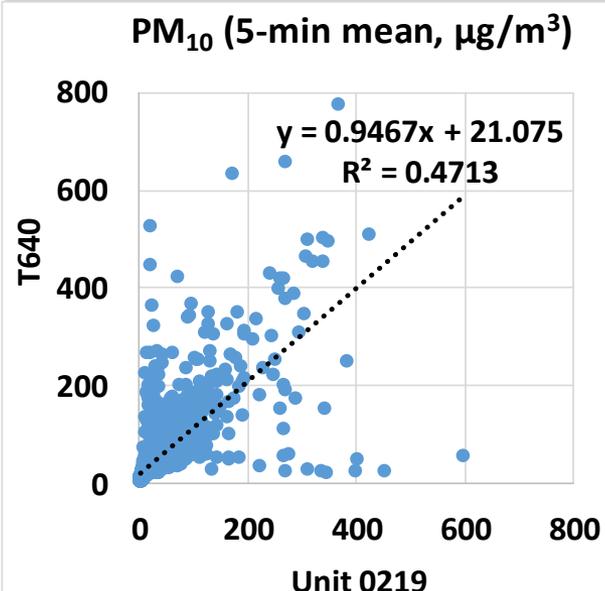
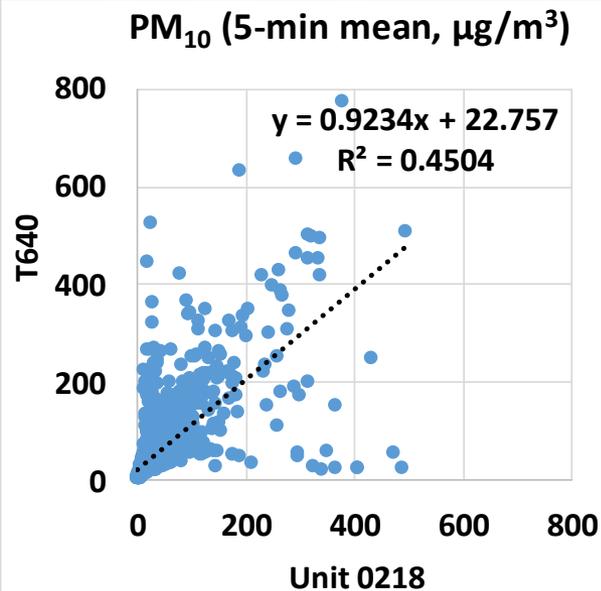
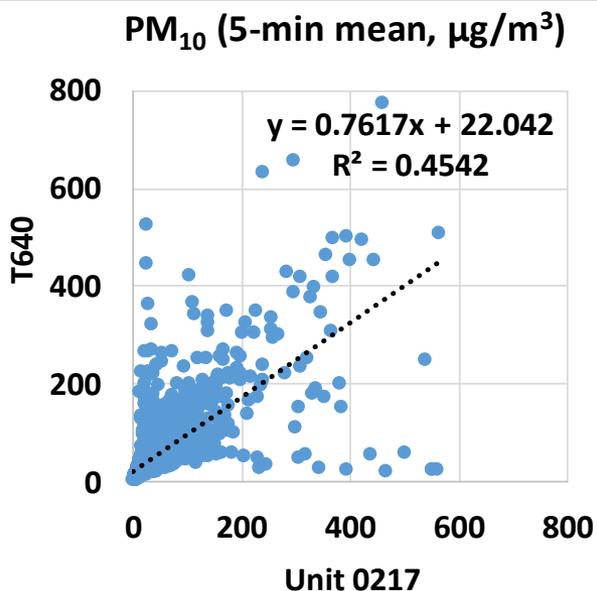
- The Alphasense OPC-N3 sensors show moderate correlations with the corresponding FEM T640 data ( $R^2 \sim 0.56$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>2.5</sub> mass concentrations measured by FEM T640 (when PM<sub>2.5</sub> is  $< \sim 50 \mu\text{g}/\text{m}^3$ )
- The Alphasense OPC-N3 sensors seem to track well the PM<sub>2.5</sub> diurnal variations as recorded by FEM T640



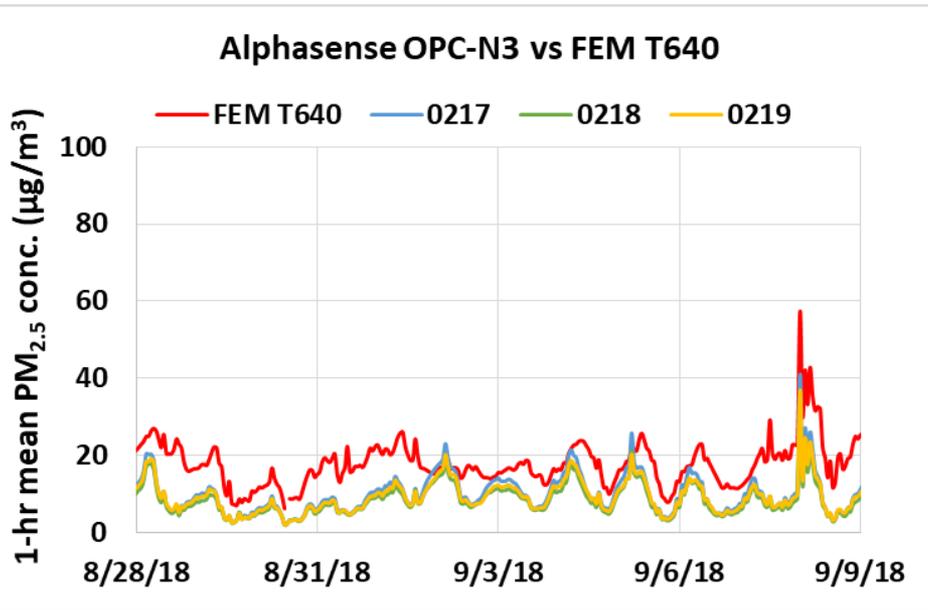
# Alphasense OPC-N3 vs T640 (PM<sub>10</sub>; 5-min mean)



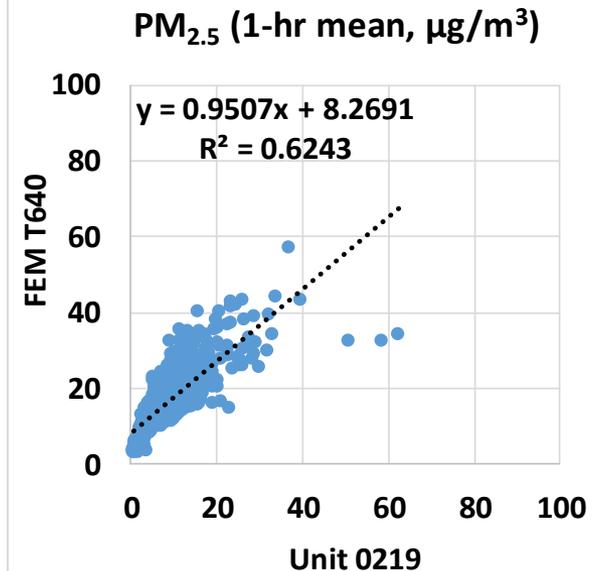
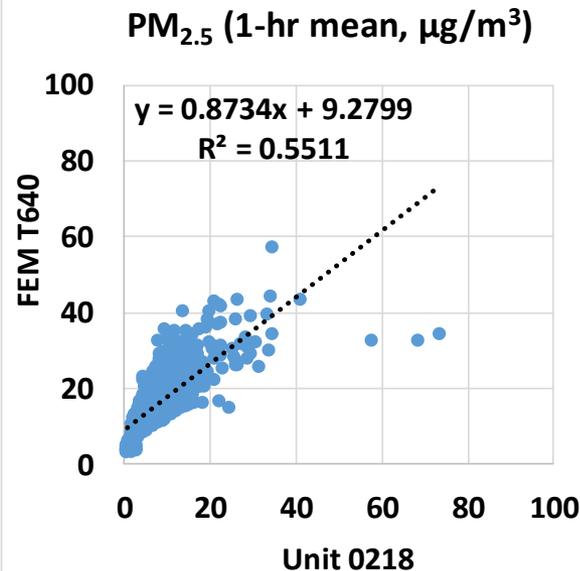
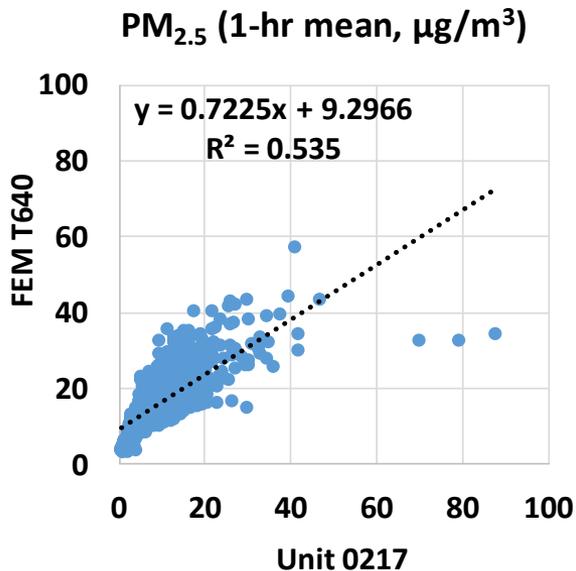
- The Alphasense OPC-N3 sensors correlate moderately with the corresponding T640 data ( $R^2 \sim 0.46$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>10</sub> mass concentrations measured by T640
- The Alphasense OPC-N3 sensors seem to modestly track the PM<sub>10</sub> diurnal variations as recorded by T640



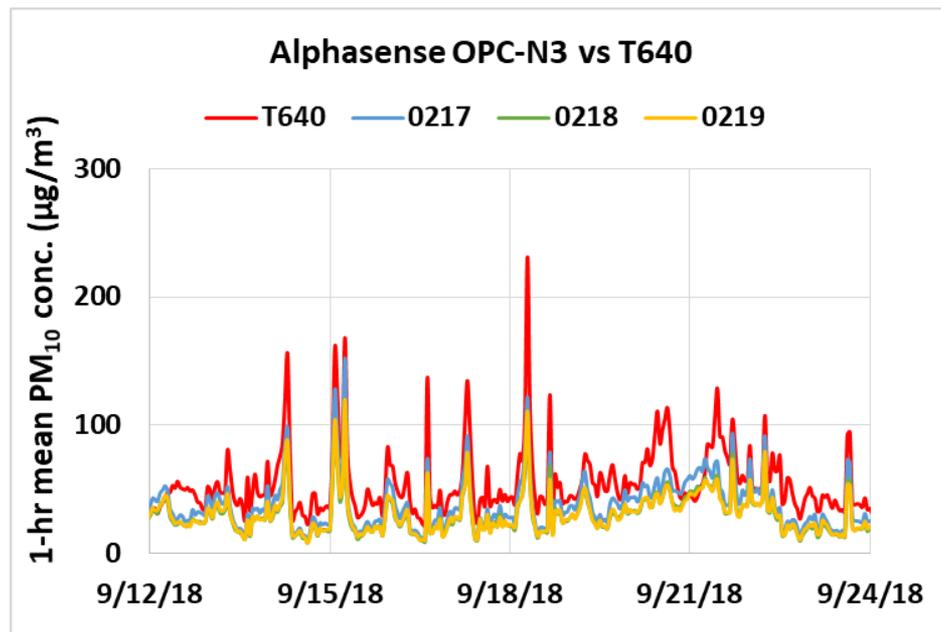
# Alphasense OPC-N3 vs FEM T640 (PM<sub>2.5</sub>; 1-hr mean)



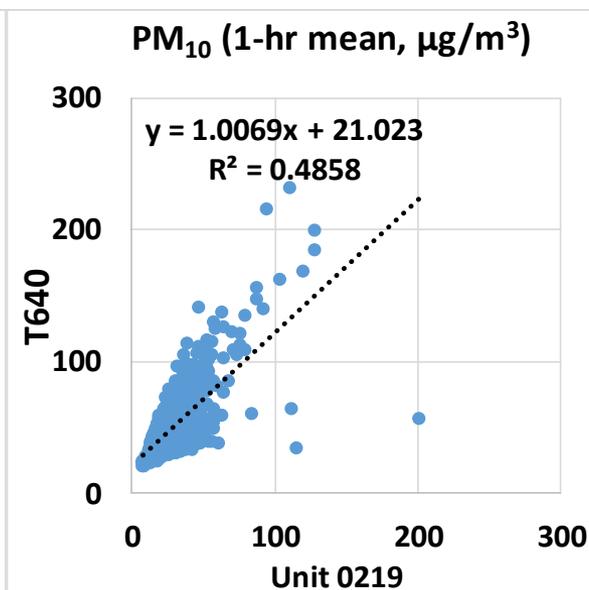
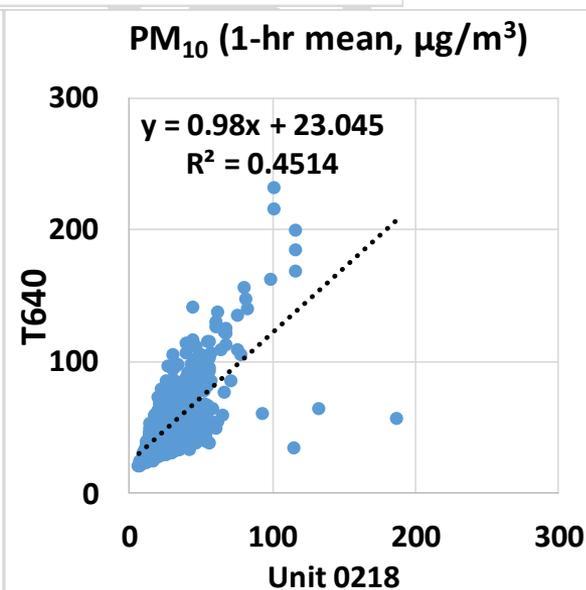
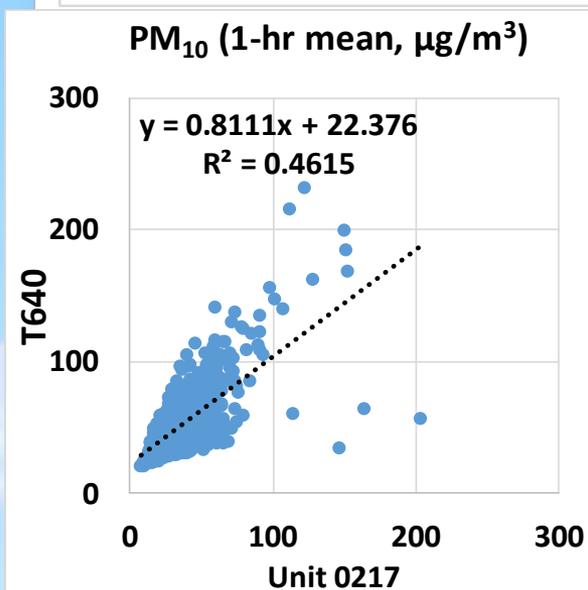
- The Alphasense OPC-N3 sensors show moderate correlations with the corresponding FEM T640 data ( $R^2 \sim 0.57$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>2.5</sub> mass concentrations measured by FEM T640
- The Alphasense OPC-N3 sensors seem to track well the PM<sub>2.5</sub> diurnal variations as recorded by FEM T640



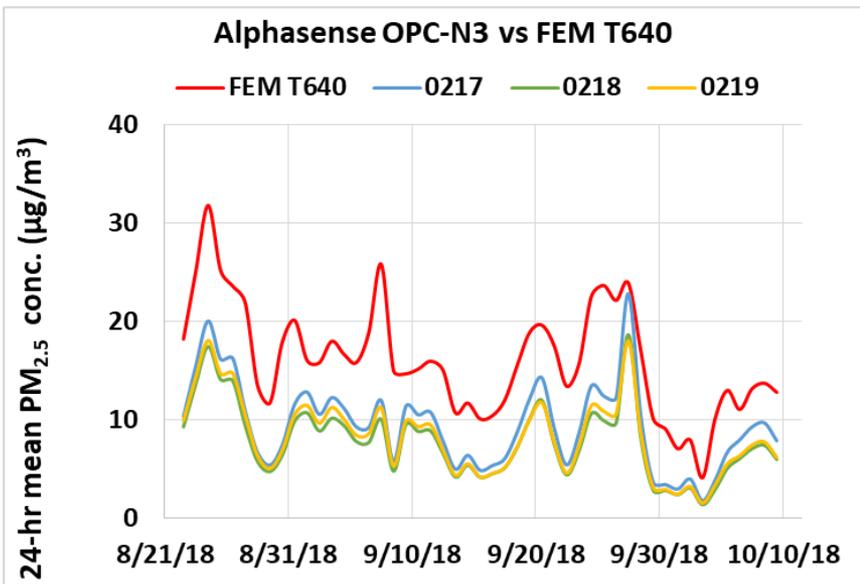
# Alphasense OPC-N3 vs T640 (PM<sub>10</sub>; 1-hr mean)



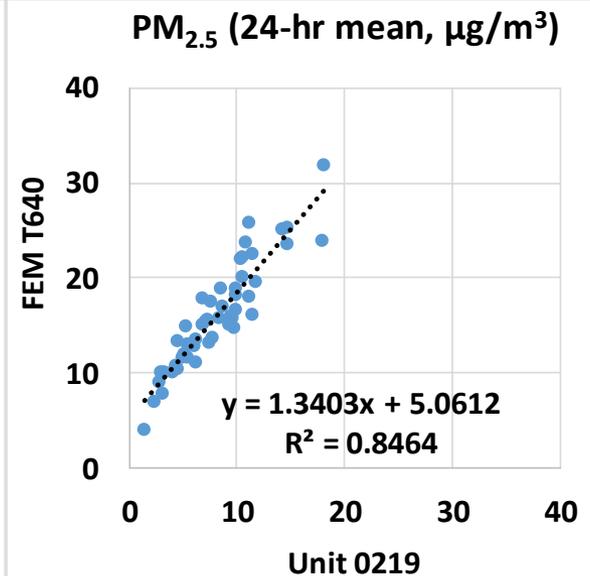
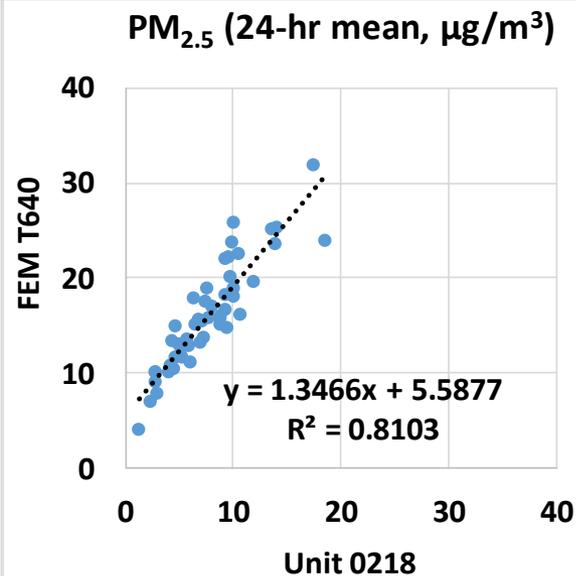
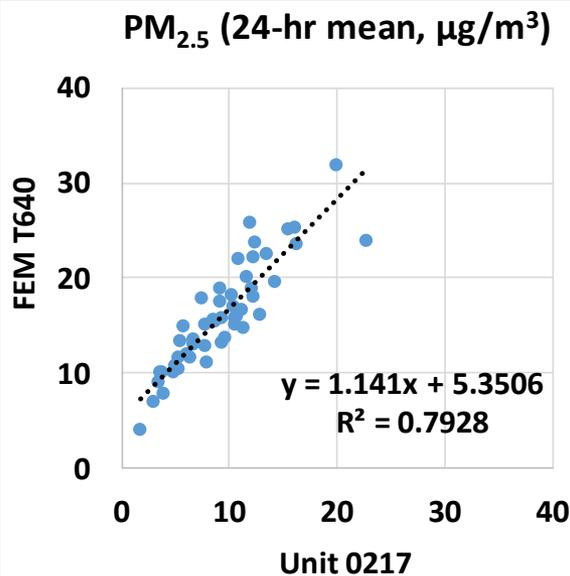
- The Alphasense OPC-N3 sensors correlate moderately with the corresponding T640 data ( $R^2 \sim 0.47$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>10</sub> mass concentrations measured by T640
- The Alphasense OPC-N3 sensors seem to track the PM<sub>10</sub> diurnal variations as recorded by T640



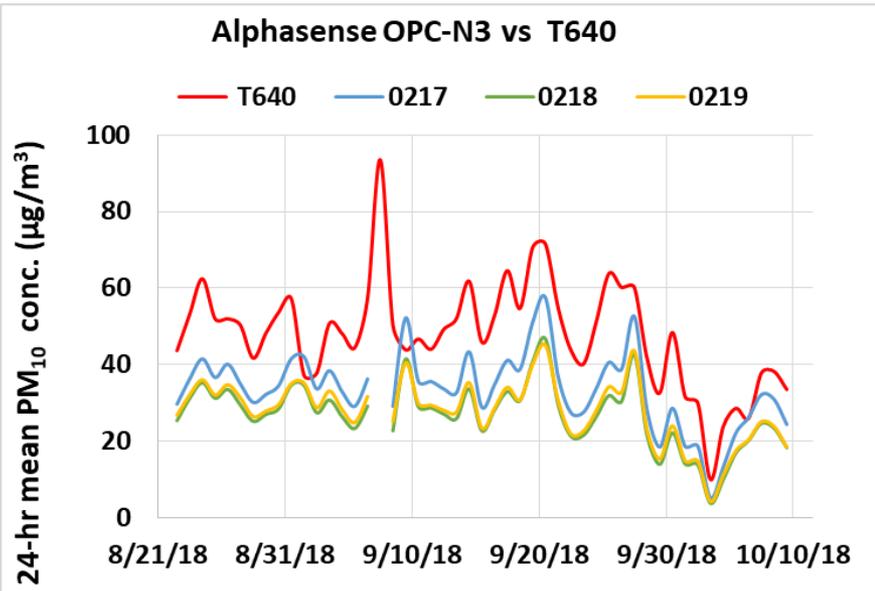
# Alphasense OPC-N3 vs FEM T640 (PM<sub>2.5</sub>; 24-hr mean)



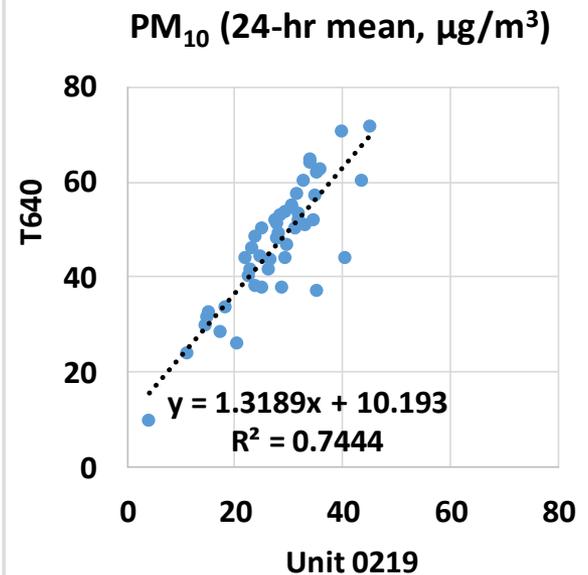
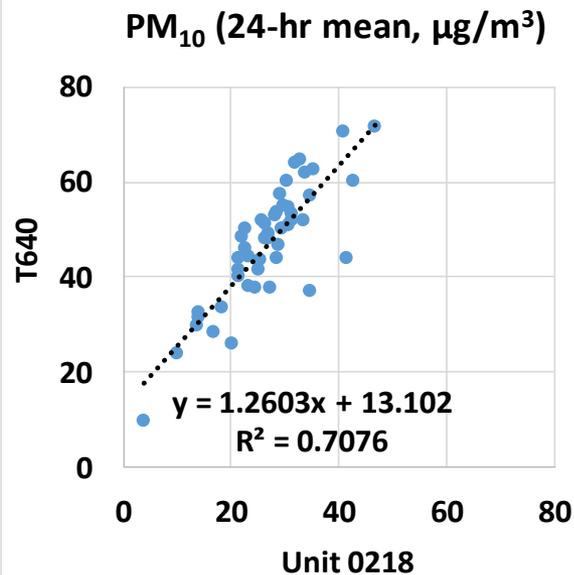
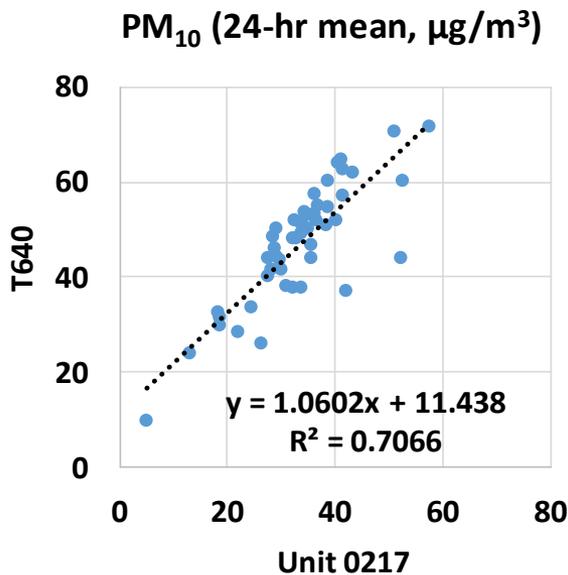
- The Alphasense OPC-N3 sensors show good correlations with the corresponding FEM T640 data ( $R^2 \sim 0.82$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>2.5</sub> mass concentrations measured by FEM T640
- The Alphasense OPC-N3 sensors seem to track well the PM<sub>2.5</sub> concentration variations as recorded by FEM T640



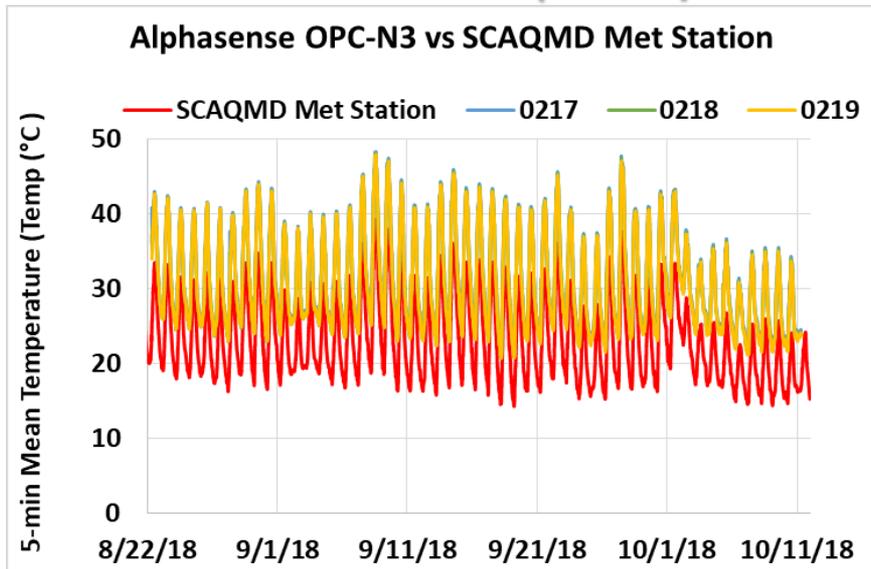
# Alphasense OPC-N3 vs T640 (PM<sub>10</sub>; 24-hr mean)



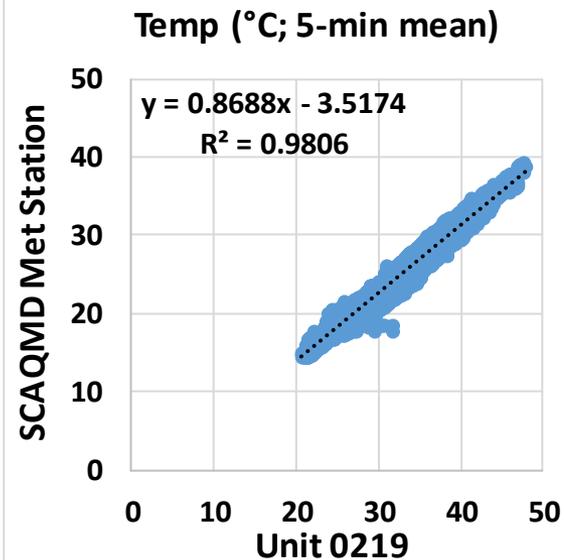
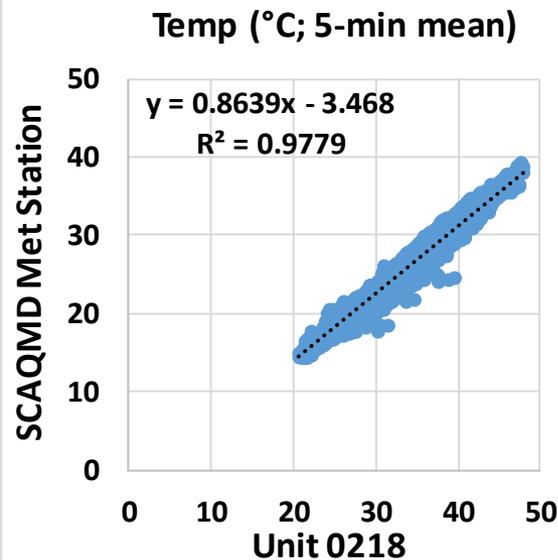
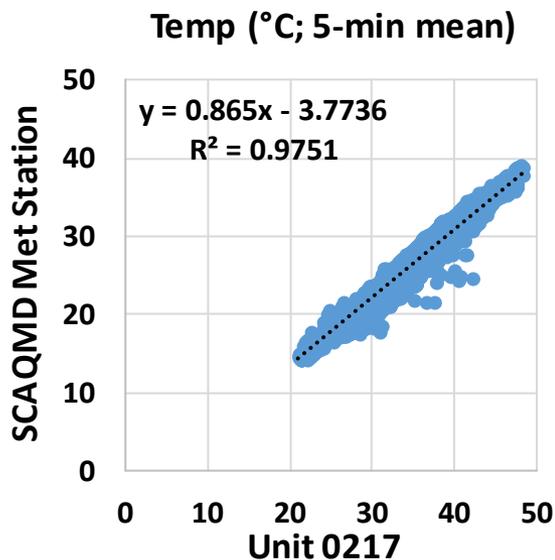
- The Alphasense OPC-N3 sensors show good correlations with the corresponding T640 data ( $R^2 \sim 0.72$ )
- Overall, the Alphasense OPC-N3 sensors underestimate the PM<sub>10</sub> mass concentrations measured by T640
- The Alphasense OPC-N3 sensors seem to track well the PM<sub>10</sub> concentration variations as recorded by T640



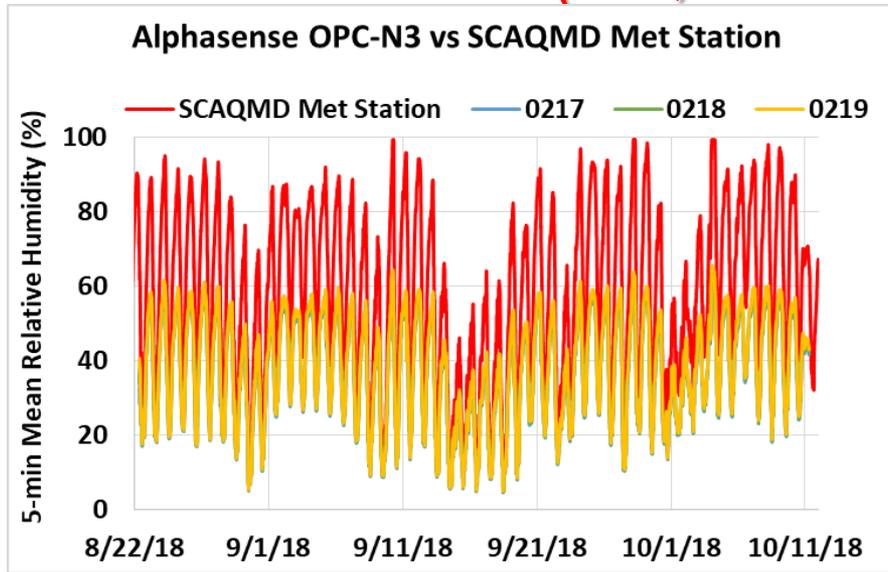
# Alphasense OPC-N3 vs SCAQMD Met Station (Temp; 5-min mean)



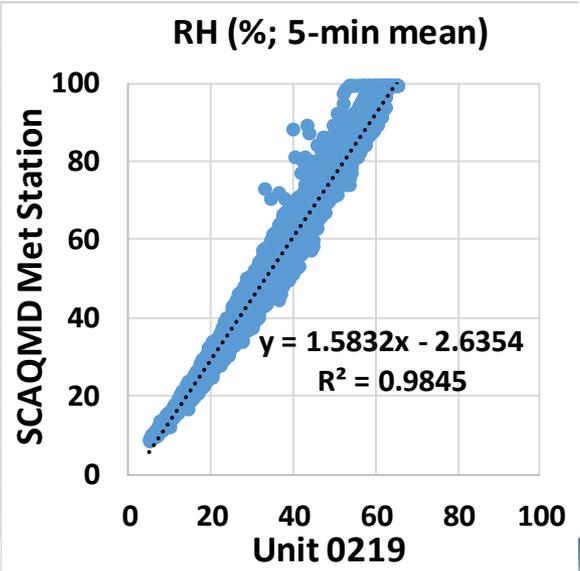
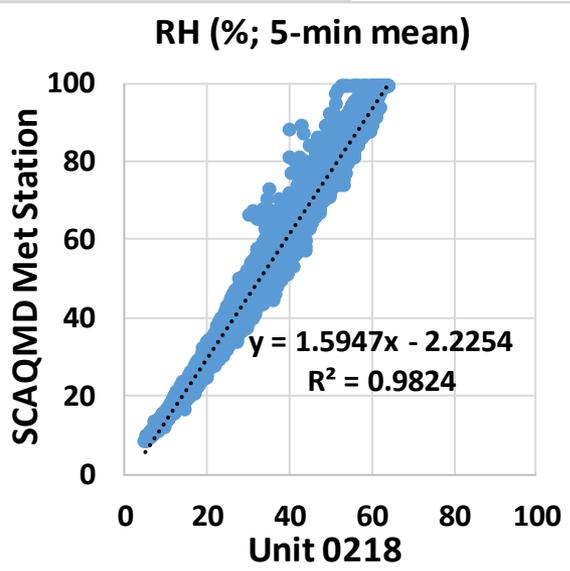
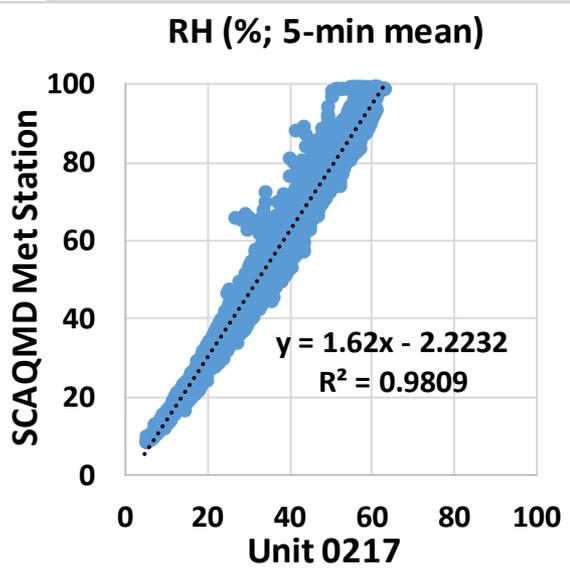
- The Alphasense OPC-N3 temperature measurements correlate very well with the corresponding SCAQMD Met Station data ( $R^2 \sim 0.97$ )
- Overall, the Alphasense OPC-N3 temperature measurements seem to be quite accurate
- The Alphasense OPC-N3 sensors seem to track well the temperature diurnal variations as recorded by SCAQMD Met Station



# Alphasense OPC-N3 vs SCAQMD Met Station (RH; 5-min mean)



- The Alphasense OPC-N3 RH measurements correlate very well with the corresponding SCAQMD met station data ( $R^2 \sim 0.98$ )
- Overall, the Alphasense OPC-N3 RH measurements underestimate those recorded by the SCAQMD Met Station
- The Alphasense OPC-N3 sensors seem to track well the RH diurnal variations as recorded by SCAQMD Met Station



# Discussion

- The three **Alphasense OPC-N3** sensors were reliable and had a data recovery of 99.8% with low to moderate intra-model variability (18% to 22%)
- The reference instruments (GRIMM, BAM and T640) correlate well with each other for both  $PM_{2.5}$  ( $R^2 \sim 0.79$ ) and  $PM_{10}$  ( $R^2 \sim 0.81$ ) mass concentration measurements (1-hr mean)
- $PM_1$  mass concentration measurements measured by Alphasense OPC-N3 sensors correlate well with the corresponding GRIMM values ( $R^2 \sim 0.80$ ; 1-hr mean) and underestimate  $PM_1$  mass concentration measured by GRIMM
- $PM_{2.5}$  mass concentration measurements measured by Alphasense OPC-N3 sensors show moderate to good correlations with the corresponding FEM GRIMM, FEM BAM and FEM T640 ( $R^2 \sim 0.64, 0.44$  and  $0.57$ , respectively; 1-hr mean) and underestimate  $PM_{2.5}$  mass concentration measured by the FEM GRIMM, FEM BAM and FEM T640
- $PM_{10}$  mass concentration measurements measured by Alphasense OPC-N3 sensors show low to moderate correlations with the corresponding GRIMM, FEM BAM and T640 ( $R^2 \sim 0.51, 0.28$  and  $0.47$ , respectively; 1-hr mean) and underestimate  $PM_{10}$  mass concentration measured by the reference instruments
- Differences from OPC-N2: 1) increased particle size range and number of channels; 2) improved inlet; 3) Equipped with onboard temperature and humidity sensor that is enclosed in raw sensor housing; 4) ability to auto switching when detecting higher range and 5) higher sampling flow rate
- No sensor calibration was performed by SCAQMD Staff prior to the beginning of this test
- Laboratory chamber testing is necessary to fully evaluate the performance of these sensors under known aerosol concentrations and controlled temperature and relative humidity conditions
- All results are still preliminary